OPINIONS OF THE WORK.

From JOHN HOMANS, M. D.

129 TREMONT STREET, BOSTON, Nov. 5, 1859.

DR. GARRATT. Dear Sir: I am happy to learn your intention to publish a treatise on *Electro-Therapeutics*, or the medical and surgical uses of Electricity.

Such a work, by an educated physician who has bestowed much time and labor on the subject, both in study and practice, setting forth the value of this often neglected and sometimes misapplied agent in the treatment of a large class of diseases, will supply a want long felt by intelligent medical men, and cannot fail to be well received.

The division of the subject into the different chapters, as indicated by you, appears judicious. I am very truly yours,

JOHN HOMANS.

From WALTER CHANNING, M. D.

"This large octavo volume is illustrated abundantly by descriptions, and drawings of instruments, both original and selected; by anàtomical sketches, and by cases in which electricity has been employed, together with the limitation of its uses. What has particularly struck and pleased us in our examination of Dr. G.'s work, is the patient minuteness which every where marks his treatment of his subject. Nothing seems to have been overlooked. It is a very valuable work."

From EDWARD H. CLARKE, M. D., Professor of Harvard University.

BOSTON, June 5, 1860.

ALFRED C. GARRATT, M. D. Dear Sir: It gives me great pleasure to acknowledge the receipt of your work on *Electro-Physiology* and *Electro-Therapeutics*. I shall read it at my earliest leisure, and hope to derive equal pleasure and profit from its perusal. The subject of *the Medical Uses of Electricity* is one of great importance, and but little understood. I hope your labors may be the means, not only of enlightening medical men with regard to it, but of awakening the attention of other observers. Please accept my best thanks for your book, and may you long be enabled to pursue the path you have entered on. . . . .

Very truly yours, EDWARD H. CLARKE.

From J. V. C. SMITH, M. D.

BOSTON, June 15, 1860.

Dear Sir: Your industry and profound attainments in the domain of that special branch of the medical profession to which your powers have been directed, as exhibited in the beautiful volume presented to me, must result most favorably for your scientific and literary reputation. It is a monument which your descendants, in after times, will contemplate with proud satisfaction.

Very truly, I have the honor to be your obliged friend and servant,

J. V. C. SMITH.

A. C. GARRATT, M. D.

From the Boston Medical and Surgical Journal.

"This volume, dedicated to our friend *John Homans, M. D.*, President of the Massachusetts Medical Society, is a very full and elaborate contribution to the *medicinal powers and uses of Electricity*. Dr. Garratt has sought, in the best authorities at home and abroad, and in their original sources, the whole literary history of this important subject, and has

presented it after a manner which deserves, and we believe *will receive*, the careful study of the profession. It is in works like this, which come directly out of the deep interest of the authors in their subjects, and *from abundant experience concerning them*, that a profession gains useful and important light, which enables it to put them to the full test of practical uses. We close with quoting the last paragraph of this very interesting and valuable work: —

"'Medical Students: Our investigations in this intensely interesting field of medical lore must here draw to a close. Let us now congratulate ourselves and thank God for this day and opportunity of seeing *understandingly* so much of this *new phase* of our noble art. I said to you in the Preface, that we were rich in the materials for a systematic work of this kind, and now say again, that we feel still burdened with the untold matter that so interests ourselves, and which we desire you to know. But the original bounds of this work are already far exceeded; I therefore only will remind you, with a parting emphasis, of the beautiful aphorism of Dr. Altheus, (who, by the way, has written well on this subject,) that "it is not electricity that cures diseases, but the *physician* who may cure disease *by the means* of electricity." In a word, it is the *method and skill* directing this agent that gives the success.'"

From the Louisville Medical Journal.

"There is no similar work in the English language; therefore this treatise by Dr. Garratt will supply an actual want heretofore felt by the profession."

From the Chicago Medical Examiner.

"From a careful examination of its contents, we are confident that the medical profession will be under lasting obligations to Dr. Garratt. The work is both *scientific and practical; a book which should be in the hands of every medical student*; and no medical library will bo complete hereafter without it."

From the New York Tribune.

"The special subject to which this volume is devoted is the medical and surgical uses of Electricity. The author has given many years to the study of the subject, and in preparing this work at the suggestion of many eminent medical men in different parts of the United States, he has combined the results of his own clinical experience with those of the highest *practical* authorities. The volume abounds in statements of the greatest interest and value to the student of physiology, as well as to the medical practitioner, and is founded on a strictly scientific basis."

From the New York Independent.

"We can commend without hesitation, to professional men, a portly octavo (now lying before us) on the '*Medical Uses of Electricity*,' by Alfred C. Garratt, M. D. This thorough and learned work is designed for '*medical students*' — a phrase which designates a very large class, inasmuch as no *good physician* ceases to be a student in medicine till he retires from the practice of his learned and liberal profession. Dr. Garratt's book, if we mistake not, *is the most comprehensive and systematic work on this subject in the English language*."

From the Philadelphia Enquirer.

"Beyond all question, there is no work, British or American, on this subject, which, for exhaustiveness and logical acuteness of reasoning, can be compared with this large and valuable treatise. All our observation of late leads us to the conclusion that there is much importance in the subject which Dr. Garratt so learnedly discusses in this treatise."

From the Cincinnati Journal of Rational Medicine.

"The past month has been somewhat prolific in the productions of publications of interest to the profession; and among the most novel and important books, no one is likely to command more attention than a work on *Electro-Physiology and Electro-Therapeutics*, by Alfred C. Garratt, M. D., of Boston. It is an elaborate and comprehensive pres-

entation of important scientific and therapeutic facts, too seldom even slightly understood by the profession. The publishers have done their part admirably, making this book a *model* one. The only objection that can be raised is, that they have made the book *too good*; and that its expensiveness may limit its sale. Price $4.00."

From the Louisville Medical News.

"It is doubtless true that the great majority of specialists are the most consummate quacks, and it is equally true that from the investigations of other honorable specialists the cause of truth has been most illuminated. It is the part of wisdom, therefore, to discriminate between these two classes. It is very easy to determine to which of these classes the author of the noble work before us belongs, (Garratt on the *Medical Uses of Electricity*,) and equally easy to perceive that he is a gentleman of learning, and a profound and practical thinker. A careful perusal of the work will convince any one, that judgment formed from the opinions or treatment of travelling or local *electropathists* may be very unjust, and that there is a veritable potency in the modification of electricity for the treatment of disease, which we may not safely ignore. The author's propositions, and the scientific bases claimed for them, are modestly suggested. The work is published by Ticknor & Fields, of Boston. It is beautifully executed and illustrated, and if the profession be true to its own interest, another edition will soon be demanded."

From the Georgia Medical and Surgical Encyclopedia.

The work before us (*Medical Uses of Electricity* by Garratt) is one which we can recommend to our friends with pleasure, for by its study they will obtain both knowledge and profit. He treats this subject calmly, deliberately, and scientifically, — an honor to himself, and a credit to his country. This work should be in the hands of every student of medicine, of every practitioner in the land. If the profession is true to themselves, their own interests, and the interests of their patients, several editions will have to be issued to supply the demand.

From the Medical and Surgical Journal, St. Joseph, Mo.

"The author (Dr. Garratt) has produced a very valuable work on the medical and surgical uses of *Electricity*; the first attempt at a complete and systematic work on this subject, we believe, ever made in America. How striking the coincidence, that Boston, the first home of Dr. Benjamin Franklin, should produce this work! We regard this book as a great boon to the profession, and as furnishing information that a majority of medical men now require, and cannot longer, with credit to themselves, fail to possess. Royal 8vo., 700 pages, 100 cuts. Price $3.00."

☞ Whoever has an electro-magnetic apparatus, or a magneto-electric machine, or a Galvanic battery, (primary current,) and intends using either of these for Neuralgia, Rheumatism, Paralysis, &c., should have at hand a copy of this work, which gives very plain and practical *directions* as to *how*, *where*, and *when* to employ electricity as a remedy with safety as well as success.

☞ By sending $3.00, by mail or otherwise, to Dr. A. C. Garratt, No. 7 Hamilton Place, Boston, Mass., the book will be forwarded free of expense. It may also be found at the bookstores throughout the country.

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Oct 23/66

ELECTRO-PHYSIOLOGY

AND

ELECTRO-THERAPEUTICS;

SHOWING THE

BEST METHODS

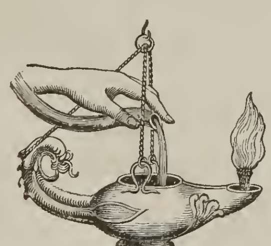
FOR THE

Medical Uses of Electricity.

BY

ALFRED C. GARRATT, M. D.,

FELLOW OF THE MASSACHUSETTS MEDICAL SOCIETY.



"STUDY, — AND SEARCH OUT THE SECRETS OF NATURE."

Harvey.

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ELECTROTYPED AT THE
BOSTON STEREOTYPE FOUNDRY.

PRINTED BY
GEORGE C. RAND & AVERY.

TO

JOHN HOMANS, M. D.,

PRESIDENT OF THE MASSACHUSETTS MEDICAL SOCIETY, MEMBER OF THE SOCIETY FOR MEDICAL IMPROVEMENT, &C.,

TO WHOM, DURING THESE YEARS OF MY PROFESSIONAL SPECIAL PRACTICE, IT HAS BEEN MY HAPPINESS TO LOOK AS A REVERED FELLOW OF OUR NOBLE ART,

MY COUNSELLOR AND FRIEND:

TO HIM, WITH FEELINGS OF ADMIRATION FOR HIS LIBERAL PRINCIPLES, PROFESSIONAL INTEGRITY AND FORECAST, AND WITH NO LESS GRATITUDE FOR HIS EXERTIONS IN THE GENERAL CAUSE OF

Medical Science,

THIS HUMBLE THOUGH ARDUOUS WORK

IS GRATEFULLY DEDICATED.

PREFACE.

MEDICAL STUDENTS: For you have I prepared this work on Electro-therapeutics, including Electro-physiology, Electro-pathology, and Electro-diagnosis. It is aimed to be a plain, practical, and systematic work. *Electricity* and *Vitality* are now known to be intimately related. It is an acknowledged fact, that medical men, at least, are not as familiar with the links of that relationship as they might be, and should be. Electricity, in its different forms and manifestations, is as absolutely and minutely concerned, according to their respective "laws of action," in every life, with health, growth, disease, and struggle for the recovery from disease, and in death, as in the grand chemistry of inanimate nature, or in the greater and mightier forces of gravitation and planetary revolution.

Vitality is more than Electricity. Life is electro-chemistry *vitalized.* This greatest force of nature, viz., Electricity, which also holds such varied and powerful influences over life, health, and disease, does assuredly command our more attentive study, in connection with other rational medicine.

The *progress* of medical science, during the past half century, has brought us into new and closer relations with almost all other departments of *physical science;* but with none, however, in so intimate and indissoluble a manner as with this of Electricity. Hence it has come to pass, says De la Rive, that the study of Electricity, as it relates particularly to medical knowledge, and *practice,* has become an absolutely indispensable study for every one who practises, teaches, or in any way cultivates science, and wishes to be *booked up* to the age and day. So also of the trades, arts, and sciences; — to the pharmaceutist and chemist, as well as the natural philosopher; to the dentist and physiologist, as well as to the geologist; as much to the engineer and artisan as to the physician; — all, all have electric forces and phenomena to deal with, and consequently each has need of becoming familiar with them; at least so far as they relate to the given trade or practice, he should be enabled to interpret them, to meet them, and to turn them to good account.

The subject matter of this work, therefore, embraces more aspects than one. It presents you not only with a reliable and potent class of remedies, (together with the best *methods* for using them,) and fairly opens a field of improved treatment for many nervous derangements and diseases, but it also affords an instructive *phase* of nature in growth, waste, and repair; in cause and cure, or disease and remedy, and of *nervous phenomena in particular;* thus throwing peculiar light on the whole range of the healing art. Indeed, it appears to me, that those who love, teach, or have to do with the natural sciences, or

who wish "to know themselves," or the philosophy of our being, particularly if medical men, — I say, no such person can possibly study this subject without the profoundest interest and substantial improvement. Physicians, of all men, should be frank towards each other. More than other men, we are dependent upon each other for facts, from which, when sufficiently numerous, we must reason up to generalization, and thus slowly discover and establish the laws of nature, as the rules of our ethics, to *comprehend* life, disease, and death. Isolated phenomena or experiments, nay, even a life-long experience in medicine, is worse than unavailing, so far as it affects knowledge and *improvement*, if it is pursued only by a dogmatic routine, or in support of a foregone conclusion. Only the one thing in that case is clearly seen; and that is, just what had always been expected, "*according to the creed*." The reasonable means, or the successive steps to the end obtained, are entirely overlooked. Let this, therefore, be our caution. We must hold, that the uncompromising lessons of careful and practical induction should attend our every step, as *special students* in this interesting but *intricate* department of science and medicine; for no conclusion has ever stood the test of time, and gained general consent with the intelligent, that is not strictly in harmony with the laws of nature, and with the moral laws of God.

The author, being profoundly convinced of the efficacy of electric currents *as a remedy*, capable of producing, often, a *radical cure*, especially in nervous affections, bespeaks a generous and impartial reception by our American medical world, of what is already achieved for and in electro-physiology and electro-therapeutics; i. e., as to what relates, in a scientific sense, to the *medical uses* of Electricity.

When Physiology is usually treated of as a science, and presented as a part of the foundation of a thorough medical education, then, of course, it embraces the whole organic nature. All classes of organized beings and organisms have there an appropriate chapter, according to the mode of development, &c. But here we give place to one grand *phase* of physiology and pathology, as a somewhat new, but soon to be realized, *indispensable help-science* to the healing art. All medical practitioners may not wish to give their time and attention, personally, to the employment of any electric apparatus; and but few may wish to make those diseases called "*Neuralgies*" and "*Palsies*" their exclusive practice; but still, no one member of an educated medical profession can nowadays be uninformed in normal and abnormal nervo-electric phenomena (that is, in electro-physiology and electro-pathology) without discredit to himself and injustice to his patient.

Pathology, young as it is, has been already admitted as an accredited witness of very peculiar importance. But a few years since, and we know that there was no professor's chair for it in any of our medical schools. Now, who does not know that it is a very "law and testimony"? Yet post-mortem and ocular pathology gives us but comparatively little insight into the deviations and lesions of the human nervous system. But, at this very weakest

point in all medical science, important yet delicate, elaborate and yet intricate as it is, Electricity comes to our aid and elicits, — *has* elicited, certain uniform phenomena, — already a "law and testimony," so far as ascertained, that can be derived from no other source. Significant facts like these do certainly demand of medical men a careful attention. Because we do not know more, or all, is certainly no good reason why we should not avail ourselves of what is already positively discovered. Much in this department of medical research will yet, ay, will *soon*, be accomplished; and brilliant will be the achievements.

The very abridged manner and immethodical style of the few works that have appeared in this country, or even in the English language, on the medical employment of Electricity, have never yet enabled the medical profession generally, particularly that of this country, to seize upon these telling facts understandingly, so as to bring them to bear upon clinical practice. On the other hand, the more complete treatises on physics enter too much into detail on Electricity, in its own wide realm, as a force of nature, or as a physical force, or in speculations upon these, for persons who do not desire to make this their particular object of labor and pursuit.

A systematic work on the medical and surgical uses of Electricity, containing clear and practical directions as to *where*, *when*, and "*how*," to employ Electricity as a remedy, (embracing at the same time the condensed scope of those natural, accidental, as well as artificial electric influences that affect life and health,) has long been greatly needed; and of late urgently *requested of the author*, by many distinguished members of the most venerable medical association in America, to fill, in some degree, this deficiency in our medical literature. True, we have had published in this country some small, yet valued treatises on this subject— one by Dr. Golding Bird; another by Dr. W. F. Channing. But these pioneer works were rather "evidence and argument," to exhibit and convince of what has, might, and would be accomplished by the medical uses of Electricity, rather than giving any philosophic and rational *exposé* of the *methods of doing it*. Therefore what has been done by the agency of Electricity, in the way of *remarkable cures*, empirically or otherwise, if the *modus operandi* is not also clearly given, is purposely excluded from this work. The author has aimed to confine himself to gleaning from the highest practical authorities, and the comparing of these with his own clinical experiences, then classifying and arranging the subject matter, so as to present the whole range of electro-therapeutics on a more systematic and scientific basis.

Perhaps it is scarcely necessary to add here, (except to forestall unnecessary and detracting criticism,) that the author has unavoidably employed the ideas often, as also the language, of others. In a work like this, based as it is *in natural science*, with a limited special literature, every one must know is but the embodying of the best of all high authority, while but a portion of the whole is truly original. Our freshest knowledge has its origin in the teachings and well-known writings of the world's best philosophers; which, after being

applied in this department of medical *practice*, becomes, in part, but a modified transcript of the originals; but in another sense or part, and that the more practical, there is conceived to be a large share of *originality pervading this whole work*, if the selecting, classifying, and *adapting* the information so variously obtained to the very purposes for which it was intended, so as to be more *practical* and *useful*, can be construed as originality. Is not this, *in fact*, (when we except accidental discovery,) the true basis of all scientific discovery and originality? In fine, the author has perseveringly labored to gather whatever is known on this subject, found in any language, *that is practical;* and that from the highest sources, and from first hands. Here he has been greatly favored by the kindness of Professor Scherb and Mr. Frederick Penard, in their readings and translations out of the Italian and German. The best of authorities have been consulted, and each has given his testimony on this part or that. From the writings of Galvani, Volta, Humboldt, Nobili, Marianini, Matteucci, Magendie, Becquerel, Marshall Hall, and Faraday; from De la Rive, Duchenne, Middeldorpff, Remak, Todd, Alfred Smee, and Brown-Sequard; from these and others have we recorded individual researches of the most intrinsic significance, as well as their individual opinions. But where quotations are made, they are duly acknowledged. Thus we find a rich field of facts for us, which have been accumulating in variety, and maturing by corroboration for the past half century. But the right or wrong interpretation of these facts, or their apparent conflicts, &c., we must leave for others to discuss. *Success in practice*, not theory, is our aim.

A work of merit, I feel satisfied, is not in the end injured by criticism, if fairly done; but this is too much to be expected every where. The author, however, cannot be surprised. No one sees so well as himself how little he feels that he knows of the length and breadth of this intricate and extensive subject; although he may be permitted to add, that he has had the honor and the advantages of the personal instructions, conversations, correspondence, and encouragements of some of the most renowned philosophers and truly experienced "medical electricians" in Europe; to which has also succeeded a ceaseless tide of bedside experiences, exclusively in this special practice; and that also during the unavoidably protracted time occupied in the preparation of this work for the press.

But to the subject directly: Careful and repeated observations of Electro-physiologic, pathologic, and therapeutic *phenomena* very soon leads us to discover *two* prominent and distinct points of view. One of these comprehends the General Laws of Electricity, in this respect; the other view comprehends the *results* arising from the manifestation of "animal electricity" in living bodies, and the action of the various forms, and methods of application of electricity, upon these bodies, and their native currents. The facts and deductions of the one require to be studied, to understand those of the other. Anatomy and physiology, also, need to be viewed through this medium, as well as from other stand-points, in order to get a true stereoscopic view of the philosophy of life, the laws of disease, and the catastrophe of death.

Under the *first division*, then, we must become familiar with the different kinds of Electricity, as Natural Electricity; also Electricity as manifested by the disturbances of nature; also with Static and Dynamic electricity, so far as they relate to our subject. Hence both the natural and artificial sources of electricity, together with the general and specific laws that regulate the given transmission of this subtile agent through the different *living* tissues, in *health*, and in *disease*, must be successively passed in review. Next comes the early history of the medical and surgical uses of electricity, Atmospheric and Terrestrial electricity, with Magnetism, Frictional Electricity, Galvanic and Electro-magnetic Currents, together with a description of all the apparatus for conveniently producing and regulating the *quantity* or the *intensity* of currents; all of which must be clearly exhibited to be easily understood. This, therefore, will compose the first three Chapters of this work.

Under the *second division*, as we may call it, we need to become no less familiar with the phenomena of Electro-physiology, in all its wonderful teachings, even from *cell-life*, electro-biology, — the nervo-electric batteries of human life, the effects of Atmospheric Electricity, — up to Animal Electricity, and the action of artificial currents, when directed for diagnosis, surgical and other remedial purposes. Diagnosis of diseases, and the Fundamental RULES for the rational employment of electricity in practice, must be seen in panoramic review. Then we examine the broad range of nervous affections, which are classed *here* under Hyperæsthesia, as, exalted nervous action, and painful affections. And another large class, under Anæsthesia, as, diminished nervous action, and all paralytic affections. Next in order will appear the Spasmodic affections, Midwifery, Surgery, Dentistry; and then the *special* cases, as suspended animation, anomalous nervous derangements, in which some given form of electricity, or particular method of applying it, has been found most beneficial and successful. Such, and more, will occupy the seven other chapters of this work, which, as a whole, I designate as Electro-therapeutics, — all of which will be found illustrated with ample *Cuts of Apparatus*, on the one part, and fine *Anatomical Cuts* of the Nerves and Muscles, &c., on the other; so as to be to the medical student as complete a work on this whole subject of which it treats as possible with our present knowledge, or as can be found in any language. Should life and opportunity be granted, the author proposes to prepare, at no distant year, a second volume, that shall be a counterpart to this — a sequel, embracing his clinical experiences, showing not only the results of purely electric treatments, but also showing the efficacy of the electric *séance*, in given cases, *when combined;* that is, simultaneously employed with the ordinary prescriptions of medicines.

When I first directed my entire professional labors to this difficult department of *special* medical practice, (after having been engaged in the general practice of medicine for nearly twenty years,) to speak mainly in the words of another, — I did so with the fullest sense of their importance, in two relations:

first, as they related to my own future career and reputation; second, as they related to the advancement of the healing art, and the immediate relief of a no small class of otherwise unreached, afflicted, and suffering persons. I was fully aware that my position, my views, and aims might excite misapprehension, because the hitherto very general association of the empirical uses of electricity, with quackery, throughout the length and breadth of our country, would naturally lead to some erroneous verdict, at least until my true position might be directly and definitely defined. For these reasons, I am all the more happy to speak for myself this day, as regards the legitimate practice of electro-therapeutics. So that, on the one hand, in regular practice, no surgeon, no oculist, no spinal, or uterine, or urinary doctor, no orthopedist, or general practitioner shall imagine that I wish to interfere with their respective positions, for which they have especially studied, and in which they are devoting their lives. On the other hand, let no wandering Arab of a boasting and quackish "Electro-pathist," Electro-physiologist, or travelling "*galvanizer*," attempt to screen himself, by using my name and address, under any connivance or sympathy, *in any of the states*, as has been done heretofore. But, on the contrary, the author feels assured that he is bringing to those same honorable men, who are engaged in special practice, through this department of medical literature, and hence to the medical profession at large, in an available form, a *tangible class of remedies;* which are also of great importance in very many respects, (besides the general principles and definite rules here laid down for specific purposes,) that every logical mind will not fail to deduce therefrom.

But one word further. Our art is *one* art. Each branch is but a part of the whole, and simply, "*e pluribus unum.*" It is too late to be sticklers for creeds or isms, for pathies or systems; only let each be honest and in earnest in his professional sphere. The author is desirous that this should no longer be termed a "*System*" of practice, but merely *the electric remedies*, &c., and that we take special pains to eradicate those false notions from the minds of the people.

I wish here to call particular attention to the fact, that almost no allusion is made in this work to the simultaneous employment of medicines with electric treatments. This is *purposely* omitted; but it must not necessarily follow that it is to be omitted in practice, if we wish to gain the greatest possible amount of improvement for the patient in the least possible time. Indeed, it will often be noticed that a skilful use of electric currents will *quicken* the action, and *heighten* the effects of internal medicines. Often, cases will be presented that promise success only in this way.

Again: like many other potent remedies now, as heretofore, employed in the treatment of diseases, electricity is greatly valued for its given effects, in certain cases, by a small portion of the profession who have thoroughly investigated it, among whom are some of the most distinguished names; while another portion of the profession, equally respectable, think but little of it; and others there are who discard it altogether. But when it is shown that the

nerves, muscles, and many of the secretions can be more surely and more uniformly called into their natural action by means of electricity than by any other known agent, and that the *degree* and *kind* of that effect is *widely different*, according to the form, quantity, or intensity of the electricity employed, and that again modified *as widely*, according to the *methods* of administering the dose at each *séance*, it is to be expected that the existing differences of opinions as to the healing power, or the manageable and remedial value of electricity, will be more nearly harmonized, and that on an intelligent basis.

It must not be thought certain that the electric current exercises an in-working influence only on or through the nerves and muscles. It is, on the contrary, my intention to aid medical men to become familiar with the idea, that all textures of the living animal body, being saturated, as they are, with the saline solutions of the blood and other secretions of the animal economy, are peculiarly accessible to the chemical and mechanical workings of the static, galvanic, and electro-magnetic currents; that these workings, as demonstrated by Dr. Robert Remak, do appear in the living human body, *within certain limits* — not simply as dissolving or chemically decomposing, (*lytic*,) so much as changing, (*catalysis*;) thus, in a degree, causing the nerves and muscles to be so largely influenced, because of their plumping up with more saline moisture, which, doubtless, enables the *ultimate structure* of all the organism to exercise more mobility in the fine molecules of their respective tissues for performing functional action. But after all, to my own mind, it is only by the most minute and slowly maturing experiences in the analogous workings of these currents in different living tissues, that insight and confidence can be obtained, which are so necessary for the rational application of electric currents for curing diseases. I trust this work will present a phalanx of facts, as well as many original, practical directions for obtaining physiological and therapeutical results, that will be found worthy of a candid attention, and lead on to fresh researches in this inviting department of medical science.

Finally, the author of this work has aimed by directness, thoroughness, and extent of practical research, thus presented by himself or by accredited authorities; by ample plates of apparatus, and of anatomy; by great simplicity in style, and freedom from technicalities as far as possible, (also by *term* Explanations,) to present this whole subject of *Medical Electricity* in so clear and simple a manner as to be readily understood by any one of ordinary intelligence; hoping it may invite into this hitherto neglected, but intensely interesting and profitable study of Electricity, as it relates to human life and health, *to the cause and cure of disease*, all ranks of the medical profession, as well as help to initiate the younger candidates for its labors and its honors, in years to come, to a still more *rational view* of diseases and their remedies; — to all of whom, or whosoever reads, it may prove an exposition of this subject at once elementary, practical, and substantial.

PREFACE TO THE SECOND EDITION.

Here, the author must acknowledge to "an agreeable surprise." When this work was about to be put forth to the medical world, the publishers, judging from past experience of the sale of books on this and other *special departments* of medicine, expected only a limited sale. Hence the price per volume was to cover the expenses. But a few months have elapsed, however, and the whole edition of this large and expensive work is disposed of. From this time, therefore, the price will be reduced twenty-five per cent., that the entire medical profession in America may be induced to investigate, more fully, *this view* of physiology and pathology, of diseases and remedies, and to avail themselves practically of its great power for good in the healing art. It certainly does afford a *new stand-point*, that is exceedingly instructive, to view the same old and familiar objects, to which all truly professional eyes are ever turned, and always love to look — viz., *Life in health*, and *Life in disease;* besides showing other accessible points to the seats of some diseases, the nature of the work to be done, and affording the very means that can do it. Moreover, the Appendix "*Notes*" *now added*, being a very plain key for the application of electricity in a variety of cases, must prove of value to the practitioner.

Pardon the author if he here reiterates, that Electricity, modified as it can be, when produced by the different kinds of scientific and philosophical apparatus, can assuredly be introduced into the domain of therapeutics with peculiar confidence, *not as a specific*, applicable in all cases to which we are called, and without distinction, but for certain cases, and in given conditions, as a reliable and powerful "*means to a definite end*," the effects of which can be foreseen, calculated, modified, directed, and controlled with as much precision, and even more provision, than can most of our frequently-resorted-to remedies.

Professional Brethren: It will be received as a favor by the author, if you will, at some time, forward to him *your own experience*, whether successful or otherwise, in the fair employment of any form of electricity. Please state your *cases* clearly and concisely as possible; give the form of electricity employed, whether sparks, shocks, aura, or current; the kind of current, whether primary or secondary; if primary, how many elements; the method; the electrodes used; the direction of the current; whether continuous, intermitted, or reversed; how often, and how many times; how long applied; how often the *seance* is repeated, as well as the whole number of sittings, and the length of time in the treatment; the amount of improvement, or cure, and how long confirmed; also, if I am at liberty to quote you in some future revision of this work.

ALFRED C. GARRATT.

No. 7 Hamilton Place, Boston, Mass.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

LIST OF ILLUSTRATIONS.

ELECTRO-THERAPEUTICS.

CHAPTER I.

NATURAL ELECTRICITY.

In the physical sciences it is now assumed that all bodies, animate and inanimate, contain a subtile influence which Philosophers have from time to time designated as *Natural Electricity.* This influence has two distinct characters. It is divided into these two parts by natural, as well as by artificial disturbances; yet is it subtile, invisible, and imponderable. These divisions are now familiarly known as *positive* and *negative* electricities, whose tendency is to coalesce, and form that equilibrium which we call natural electricity. The particles or molecules of the one kind, always attract those of the other, or opposite kind. The molecules of the same kind, be they positive or negative, always repel their fellows of the same order. Although ever tending to obtain a counterpoise for a rest, yet as easily and perpetually are these two electricities unbalanced, even so sure as our revolving globe receives her accession, duration, and declination of solar rays. So also, whatever disturbs any molecule of matter, fluid or solid, as heat, friction, or chemical action, as also magnetism and vitality, liberates *active electricity.* The relative greatness of quantity and of tension of the given electricity, varies even to the greatest extreme, according to its source; but its nature is always one and the same.

It is presumed that every intelligent practitioner of medicine, in these days, understands the fundamental Laws of Electricity; but the author makes here a free but easy rehearsal of so much of those *laws* and *conditions*, to which in its respective forms Electricity is obedient while acting upon, or traversing through, the different living tissues of the human organism, as will prove a sufficient *vade mecum*, in its department, for ready reference to the working practitioner. Certainly no conscientious and high-minded person would be willing to attempt to employ this powerful agent in any form on the human body, *actively*, as a remedy, and much less as a trifling experiment, without first being familiar at least with the outlines of its sources, its properties, its actions, and its results.

Sources of Electricity.

There are usually acknowledged *three principal sources* of appreciable Electricity; namely, heat, mechanical friction, and chemical action. While inanimate bodies are at rest, there is no appreciable electricity to be found. The positive and negative exist in them in such proportions, that, although they do not destroy each other, their effect is counterbalanced, and their very existence is masked. Under the same distance and circumstance, the attractive power of the one is equal to the repulsive power of the other. This natural rest of electricity must therefore be disturbed, in order to produce any *appreciable* existence or action.

The earliest mention of electricity is supposed to have been by the Ionian philosopher, Thales of Miletus, who discovered that if a smooth piece of amber was rubbed with a dry cloth it attracted various light bodies that were placed near it. Although he was reckoned as one of the seven wise men of Greece, it is also recorded of him, that from this phenomenon he supposed that amber possessed a soul, and was thus nourished by the attracted bodies. This was at an early day, however, for he died in the ninety-sixth year of his age, about five hundred and forty-eight years before the Christian era. Pliny the elder also

speaks of a hard, violet, or deep-red colored stone, which, when heated in the sun, and then rubbed with the fingers, would attract small light bodies. We now know that when a piece of amber, wax, or glass is rubbed with a dry cloth or fur, it acquires the property of attracting light bodies, as pith balls, or bits of paper, because the friction has decomposed the natural electricity of the amber, or wax, so that it has become "*minus*," as Dr. Franklin would say, or resinous and *negative*, as it is now more familiarly termed; i. e., the negative electricity is thus accumulated in a state of rest in the rubbed, non-conducting body; so that if now it is approached by any light body, a law of electricity is observed, and the bit of paper, for instance, is attracted to the amber, and that neutralizes a given portion of its single electricity, but still adheres to it. If the paper were larger, so as to neutralize all the negative electricity of the amber, it would then instantly leave by repulsion. This kind is therefore termed "*frictional electricity.*"

A quiet and simple elevation of temperature, is also alone sufficient to render a body electrical which was not so before. This is termed *heat*, or *thermo-electricity*, to distinguish it from *pyro-electricity*, which was discovered first in the tourmaline and then afterwards in other crystals and precious stones; also to designate it from *hydro-electricity*, which was a term early applied to voltaic electricity, and which is the same as galvanism.

The third great source of electricity, then, is from chemical action; and this is termed *dynamic* or *voltaic electricity*,—so called after its distinguished discoverer, and also because it is in currents or motion. It is, as just said, also termed *galvanism.* But there are also two other important sources of electricity; and these are magnetism, and the animal body. These will severally be considered under their respective heads; but we must observe that there is another phase of electricity which we should notice, and that is, first, *electricity at rest*, as accumulated in or on a non-conductor, and hence termed "static electricity," and second, *electricity in motion*, as from chemical decomposition, &c., and hence termed "dynamic electricity."

Nature of Electricity.

It is important, before we go further, for us to form an *idea* of the properties of electricity, or, in other words, of what electricity *is;* at least, to be reminded of the opinions that have been formed on this subject. The knowledge of these theories, as has been remarked, is absolutely necessary for us, even were it only to make us familiar with the established expressions employed by writers on this subject. But all this will be more fully and naturally explained, in connection with the history of the development of this branch of science. Here then, we will only stop to mention certain prominent opinions.

Dr. Benjamin Franklin's theory consisted in admitting but one single imponderable *electric fluid*, very subtile, and that all the particles of which mutually repel each other; that each body has a determinate capacity for this fluid; that a body is in a natural electric state when it contains as much as it ought naturally to have. He held that to electrize a body vitreously, is to give it more electricity than it naturally contains; and when so conditioned, the body is in the *positive* electric state. To electrize a body resinously, is simply to deprive that body of a portion of its natural electricity, and then it is in a *negative* electric state. So that Franklin's theory gave rise to the terms *positive* and *negative* electricity the world over. But his theory of simple *plus* and *minus*, just as he gave it, cannot, in the present state of the sciences, be admitted.

We now regard the two electricities, the vitreous and the resinous, as excessively subtile and imponderable fluids or influences, each of which orders is composed of particles that naturally repel each other, while the particles of the one order as naturally attract those of the other order; that these different influences or fluids are able to travel in and through conducting bodies; yet as their fellow-particles of the given order tend to repel each other mutually, they therefore, when on insulating bodies, arrange themselves on the surface of these, and remain, because they meet the dry air, which being to them an insulator, they can go no farther. Why a given article, as amber or glass,

is a non-conductor, or why these two fluids are so restrained in their movements, until they accumulate to a given degree, we cannot further explain, than to attribute this to their being held by the peculiar particles of these bodies; but that when these two influences — positive and negative — do unite by virtue of their mutual attractions, they then become *one* natural electricity, which is neutral, the relative action and influence of which is insensible. Such are the more modern and commonly received views, which are indeed based upon the celebrated "*Symmer's two-fluid theory*."

M. De la Rive, however, says, "We may for the present say it is very probable that Electricity, instead of consisting of one, or of two special fluids, *sui generis*, is nothing more than the result of a particular modification in the state of bodies, which modification probably depends on the mutual action exercised on each other by the ponderable particles of matter, and the subtile fluid that surrounds them on every side."

Thermo-Electricity.

From the earliest times philosophers observed that *heat* facilitated the development of electricity, particularly if it was attended with friction, and on insulating bodies. M. Becquerel lays down as fundamental, that the propagation of heat, at least in a metal, is always attended with a liberation of electricity, and that the current is from the heated end towards the colder end of the bar. Thermo-electric currents are *not instantaneous*, like those of induction, and for that reason thermo-electricity is not calculated for the production of electric currents, except in particular cases, as where we are more concerned in *studying the effects* of dynamic electricity, than in producing effects, or determining the laws of its propagation. The *thermo-electric pile* of Nobili, formed at first of only six dry pairs of bismuth and antimony, has been greatly multiplied and improved, so that it now constitutes one of the most sensitive and delicate means known for appreciating differences of temperature. M. Melloni improved this by composing a pile of some fifty small and slender

bars of bismuth and antimony of about two inches in length, so soldered together alternately and folded back and forth upon itself, as to form a very small compact cube, or block, by means of insulating wax, or shellac, for filling the vacancies between the bars, which must touch only at their solderings.

The two extreme ends of this sort of folded chain, the one of

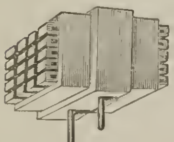


Fig. 1.

bismuth and the other of antimony, which are the poles of the pile, connect, by two short bits of ordinary insulated copper conducting wire, with the two extremities of a multiplier. The two studs pass through a piece of ivory, or glass, fixed upon a metal ring, which receives the thermo-electric block, and may be furnished with a pivot, or a hinge, by means of a piece attached, and so allow the axis of the pile to be placed hanging in any direction. The face of this instrument, that we now wish to be kept at an *ambient* temperature, must be covered with a finely-polished metal shield, which so envelops it as not to touch it; while care must be taken to blacken the terminal faces of the pile, which is to be uncovered and turned directly facing the source of the heat, or cold, that is to be tested. The nice sensibility of this apparatus, small and exceedingly simple as it is, we learn from M. De la Rive, is such, that if the uncovered face of this little pile is turned towards a person who stands at a distance of even twenty-five feet, the deviation of the needle of the multiplier *detects* the emanation of the radiant heat of that person, and shows the evidence to all who behold! By this marvellously delicate instrument, MM. Nobili and Melloni were enabled to discover the presence of heat even in *insects* — in phosphorescent bodies, and under many circumstances where it could not be detected by any other known means.

M. Becquerel has taught us to make use of thermo-electricity for the measurement of the temperature of the different tissues of the human body, by preparing mixed metallic needles of a diameter of less than a twentieth of an inch, which are used simply by introducing them as we do acu-puncture needles. Then, if we compare thoroughly, yet very carefully, all the phenomena in which heat and electricity are concerned together, we

every where discover molecular influence becoming very manifest; *the passage of the artificial electric current, by increasing the polarity of the atoms, exalts their velocity of rotation, and this again increases their individual electric polarity.* The idea thus put forth by M. De la Rive, and Dr. A. Smee, that atoms have an electric polarity, which they owe to a more or less rapid motion by rotation, leads us to think that if this facility for actual increase of rotation is truly augmented also by moderate heat, and at the same time it exalts their electric polarity, we may, in some measure, and I think in a very satisfactory manner, account for what takes place in living bodies, as electro-calorific phenomena, since this applies mostly to *moist* tissues or fluids.

Static Electricity.

It is true that natural electricity is at rest, because it is neutral; but this is not what is meant by static electricity, although it also refers to an electricity at rest. But where the natural electricity of bodies has been decomposed, as by friction, heat, or decomposition, then there is a separation of the positive and negative, the one occupying a given locality, and the other another, in a state of accumulation and rest, as on insulated and non-conducting bodies. This state is also called *electric tension.* Hence, when the electricity that is produced by the friction *electrical machine* is spoken of, in connection with medical practice, we always designate it as *static electricity.* This form of electricity, above all other forms, exercises the most remarkably attractive and repulsive powers, even at a distance. But the energy of these properties are in proportion to the tension and distance. The neutralization of these two electricities is usually instantaneous and by a spark or shock. The neutralization can take place slowly and imperceptibly, as through imperfect conductors. The *quantity* of frictional or static electricity is always relatively small, but it possesses the highest degree of *tension.* For this reason it is easy to draw very brilliant sparks from the electrical machine, while large and powerful series of galvanic batteries, which furnish an enormous quantity of electricity, (but

of less relative tension,) will produce only the least spark. Now, if these two kinds of electricities, i. e., positive and negative, be constantly renewed, there will likewise be a continuous neutralization, either through the air as a fine succession of sparks, or through a conductor in contact. The essential difference between a *discharge* of electricity, and a *current* of electricity, as they relate to physiology and therapeutics, will be plainly delineated in this work. I will only mention here, that a discharge or shock, although it produces a number of other powerful effects, has almost no chemical effect and no influence on the magnetic needle, whilst all *currents* of electricity are able to accomplish both.

We find that we can produce electricity instantly and constantly; but the *accumulation* of electricity is a matter of time. And here I must remind you of an electric law that is not so known, or else is more generally forgotten; and that is, that one of the electricities by friction is never liberated without the other or opposite electricity being equally so, and that in the same proportion. I mention this as a particular reminder, because a provision must for this reason be always made for the escape (as for instance to the earth) of the electricity we do not want, *in order* to obtain freely and largely that other kind which we do want. This law, first laid down by M. Wilke, applies also to other forms of electricity, but all the more distinctively in this, where one only of the electricities is collected, as for instance when highly charging the Leyden jars. True, Faraday caused two bands of flannel to be rubbed against each other crosswise, and thus both were rendered negative. But this is an apparent exception, although it can be explained.

Finally, we are taught that the kind of electricity that is developed upon a body does not depend solely upon the nature of this body, but likewise upon that of the substance with which it is acted upon, or rubbed, as one electricity is never developed without its opposite; and either of these may prefer to accumulate on the one or other body. There is *not*, therefore, an identity between the electricity that glass acquires by friction, and which we call vitreous, and that which wax acquires, and which

is termed resinous, since on each of these bodies, although electrized in the same manner as exactly as possible, the effect of the former is *repulsive*, and that of the latter is *attractive*. As experiments teach us that all bodies in nature upon being rubbed acquire one or the other of these two electricities, the following law is deduced: —

1. That there is an attraction between two bodies electrized, the one as by glass, the other as by wax.

2. That there is *attraction* between an electrized body and a body that is not so.

3. That there is a *repulsion* between two bodies that are electrized by the *same* source of electricity, and consequently if possessed of the same kind of electricity, whether that be positive or negative.

Dynamic Electricity.

While the naturalization of an appreciable electricity is being brought about, either through the air as a spark, or invisibly through a conductor, it is said to be in a *dynamic* condition, for it is moving. This term is therefore applied to all electricity *in motion*, as where the positive and the negative are supposed to be travelling towards each other through a conductor, and constituting a current, and at the same time neutralizing each other. This denomination includes therefore all electricities that are not included in the denomination of *static*, as before mentioned; but we must here except natural electricity.

The dynamic state of a given electricity may be only *instantaneous*, or it may be more or less *continuous*. It is instantaneous when there is an *electric discharge*, and consequent neutralization of the accumulation; or it is continuous where there is a source of constantly renewing supply, as through a closed conductor of a battery, and this is termed the continuous dynamic condition, or *electric current;* and hence we say that the con ductors, and whatever body is included between the poles of those conductors of a battery, are *traversed* by a current. And here lies the gist of the whole matter: the works that can be accomplished between these two tips of wires, called *poles*,

already telegraphing nations with a harmony of intelligence, besides performing every day a thousand other useful works, must also be brought to the aid of our enfeebled bodies, or deranged nervo-telegraph systems, to vivify, to restore communication, to clear them of their debris, and enable them again to regulate their more normal and constantly-renewing supplies. We find also the general principle, that every disturbance impressed upon a body — and this peculiarly applies to the living human body — from which arises any change, or even the slightest disturbance in the state of its molecular equilibrium in any department, is strictly accompanied by a like production of electricity, which is manifested more or less according to the physical and chemical condition of the body so disturbed.

To sum up, then, we are able to show a rigorous principle that is now fairly demonstrated, viz., that not only friction and heat, but also *every sort* of mechanical and chemical action which disturbs the minutest particles of the human organism, becomes the producer of electricity in that body; which, in the living body, we see manifested through the nervous media — first, for healthy function; second, for diseased action. In health, and within certain bounds, electricity does not accumulate in the body, nor yet does it greatly diminish, as occurs in disease, because the two electricities for the most part tend to recompose to a balance, and so become quiet; yet at the same time the same process is continually succeeding. Indeed, we are enabled to prove by direct and conclusive test, as by the aid of a sensitive galvanometer multiplier, that every minutest chemical action gives rise to an electric current. This action may be that of a liquid upon a solid, or upon two solids, or of two liquids upon each other, or of a gas in connection with any of these, under certain conditions, or it may be that peculiar action which characterizes all the phenomena of slow or rapid combustion. But all this will be more clearly illustrated in Electro-physiology.

ATMOSPHERIC ELECTRICITY.

A little over one hundred years ago Dr. Benjamin Franklin, the illustrious native of Boston, Massachusetts, first of all obtained the proof that the lightning and thunder of the clouds, are due to electricity alone, and are indeed the same as electricity artificially produced by means of friction accumulated and discharged by the Leyden jar. True, this was strongly conjectured in all those years, as indeed it had been by the Romans for centuries before, but no one could prove it. In physics, it is experiment and demonstration, first and alone, that can decide. Therefore our Franklin resolved to send into that region of thunder, and bring to earth *a spark of evidence*, which he actually accomplished in 1752, by means of his famous kite. And this proved a satisfactory answer. By it the learned world was truly electrified. New interest every where burst forth in this field of natural science. At once, from the city of Mexico to Moscow and St. Petersburg, kites were flying in the service of philosophy. Other effective means were also soon devised to witness this then new and extremely interesting phenomenon. M. de Romas, in June, 1753, raised his kite for this purpose, with a very fine copper wire inlaid through the whole length of the kite-string; and thus he obtained most wonderful effects. It is said that he drew from the kite, which was thrust high into the midst of the shower clouds, sparks or streaks of lightning from eight to ten feet long, and one inch in diameter. Notwithstanding his precaution, in using large glass insulators, with which to hold the kite-string while experimenting, he was knocked down by a shock, but was not killed. Professor Richmann, of St. Petersburg, however, erected a tall iron rod for the same purpose, and during a thunder storm it led a bolt of lightning into his house. The rod not being well connected with the ground, or perhaps not at all, as he stooped down to watch the experiment at the bottom of the rod, and near the

floor, he was struck in his head and killed instantly. Lightning and thunder, then, is but a simple discharge of electricity, only on a large and magnificent scale.

Clouds.

We may notice, without the weather being decidedly stormy, that the very presence, in the otherwise serene atmosphere, of a small or thin, fine cloud, or of the fall of a few drops of rain, or a few flakes of snow, *is sufficient to modify* the normal state of electricity in the air. But this is far from possessing the importance that results from the existence of a storm, a dense fog, or thunder and lightning, with wind, rain, hail, or snow.

The mere formation of a single cloud, or of the slightest fog, is accompanied with a sensible disturbance of the electric state of that stratum of air in which this formation takes place. The aqueous vapor with which the atmosphere is always more or less saturated, being usually invisible, becomes in the clouds and fogs visible; and we know that their globules are so many small spherical balloons, in which a small capsule or pellicle of water serves as an envelope to the interior air, which is polarized. We have only to place an electroscope in the middle of a cloud, or fog, when driven by the wind, and we see how greatly the divergence of the needle varies with the passage of the successive flakes of denser portions of the fog or cloud.

Now, to understand in some degree those wonderful electric phenomena of clouds over and about us, and which are so full of meaning, it is well, and indeed necessary, to be more familiar with the individualities of each of the globules of which they are composed. But this must not be entered upon here. I will only remind you, that the globules themselves are grouped by small flakes, which have their limits and their spheres of action, much like the globules themselves; the small flakes, by grouping, constitute the large flakes; the latter group and form *Mamillæ;* a certain number of these again, by their reunion, form a *Cloudlet;* and the cloudlets marshal by a law into given definite clouds; and these again, grouping as so many individual and definite

clouds, thus result in a *Cumulus;* and several cumuli organize into a *Nimbus.*

Then, again, the clouds themselves, if we except the invisible clouds, are distinguished as three grand species or kinds: the *Cirri*, which have the appearance of loose filaments, and fly the highest; the *Cumuli*, which are less elevated, have a rounded appearance, and form the large clouds which we see usually accumulated or formed at the horizon, and which we fancy so resemble the gorgeous sight of distant mountains when covered with snow and sunshine; or as if the looming and approximating of the very land of Beulah. The next are the *Stratose* clouds, which are horizontal and parallel stripes, or bands, forming at sunset, and disappearing again between break of day and sunrise. We observe that when the *Cumuli* are piled up, and become quite dense, they then pass into the compound state of *Cumulo-stratus*, which themselves shortly after pass into the state of *Nimbi*, or true rain clouds. These latter are distinguished by their uniform gray tint, with fine fringe edges; this, however, soon passes into the uniform, undefinable, and extensive *Storm Clouds*, which are peculiar for being without visible edges.

Thunder clouds are usually formed during the heat of summer days, from the occurrence of a rapid condensation of the vapor with which the atmosphere is then saturated. When this watery vapor, or evaporation from the earth's surface, reaches an elevation where the condensing power of cold (magnetism?) is sufficient to overcome the repulsive force of the electricity that attends the vapor, then thunder clouds are speedily formed, and the electricity, like latent heat, becomes sensible in the condensed vapor of that cloud. As the earth is the great reservoir of electricity, so is evaporation the principal and perpetual agent in conveying off the earth's surface electricity so abundantly to and throughout the upper strata of the atmosphere. The evaporation of the earth's moistures is too extensive to be computed and comprehended, and yet it is this mighty force, that, particle by particle, carries off and up to the sky such prodigious quantities of electricity, which particles themselves are rendered all the more volatile by the self-repellent effects of the minute po-

larized electricity which they severally contain. As these minute globular particles increase in density and extent, the tension of their free electricity becomes greater, until this speedily reaches such a degree as to overcome the resistance of the non-conducting air, when a discharge of lightning takes place, either to the earth or to some other cloud less charged.

Thunder clouds are often negative in regard to each other, as also in regard to the earth; in that case the lightning is seen to leap from one to the other, until the equilibrium is nearly or quite restored between them. But it is the new and *isolated* thunder clouds, those which form so rapidly from vapor condensed by the violent meeting of very warm and very cold currents of air, that present the highest degree of electric excitement, and exhibit the most terrific electric phenomena. As the thunder storm and shower clouds now approach, the flaky portions of these clouds are observed to be in the greatest commotion by a whirling and flying of various detached portions, and a scudding of other fragments to other denser portions, as if to find an adjustment—the whole having a dismal, dark, or black and threatening aspect, which are instantly and fearfully augmenting; and then comes the blazing of frequent discharges of lightning, followed by, or almost simultaneous with, crashing peals of terrific thunder, and that with torrents of rain. These thunder clouds, then, may be regarded as a huge panorama of electric batteries suspended in the sky and insulated merely by the surrounding air.

Thus prodigious quantities of electricity are restored to the earth's surface again by the lightning and the falling snow or rain. But M. De la Rive believes that a still greater quantity of electricity from the higher regions of atmosphere RETURNS to the earth *at the magnetic poles*. Thus the quantities of electricity which pass into the air in all the equatorial and temperate regions, flow through the air in currents towards the north and south poles, and are there discharged into the earth at and about the magnetic axes; and from thence flow through the earth back again *towards* the equator, for reëstablishing the equilibrium.

This philosopher believes that such a process accounts for the beautiful, but often *pain-attending phenomena of the aurora bo-*

realis. The gentle flashes and streamers of auroral light, he thinks, are caused by the passage of unusual quantities of electricity from the regions above, to the negative pole of the earth. But that this is also connected with the magnetism of the earth, is quite as evident from the fact that the magnetic needle is found to be more or less affected by the north, or perhaps the south currents, during these gorgeous dissolving views of auroral exhibition. The irregular and augmented action of the electro-magnetic telegraph during some days, causes *registers* to operate as if in contact with a powerful battery, and thus gives the signal of this as yet unseen, but *felt*, atmospheric phenomenon, which is usually verified in the evening by the appearance of the halo and streamers of an aurora borealis.

This is admirably demonstrated by causing one of the poles of a straight magnet, that connects with the moist earth, to enter the glass globe of an air-pump. Above and around the upper end of this magnet is placed a metallic circle. Now, upon removing the air from the globe, and charging the circle with the electric machine, there appear the halo of dim light and the streamers of a miniature aurora.

Meteorology.

It is profitable and interesting to know in this connection, that Meteorological observations have now become multitudinous. These, conducted by so many scientific persons, and in so great a number of countries, as well as under so great a variety of circumstances, and that for so many successive years, appear to us calculated to inspire the greatest confidence, so far as the facts are agreed upon. The following table, formed by the distinguished De la Rive in 1858, has made manifest the following concise results: —

1. Whatever the state of the sky may be, the electricity of the air presents a maximum or *greatest* tension in January, and a minimum or *least* tension towards the summer solstice.

2. The difference between the maximum and the minimum is much more sensible during serene weather, than it is during cloudy weather.

3. During the different months, generally, the electricity of the air is more powerful when the sky is serene than when it is cloudy, excepting towards the months of June and July, when the electricity attains its maximum; the value of which is nearly the same, whatever be the state of the sky.

Thus, setting out with these views, the electricity of the atmosphere during a serene sky exceeds the electricity observed during a cloudy sky, and so much the more as we approach nearer to January. *In this latter month the ratio is more than four to one.* Now, this powerful atmospheric electric intensity, during the serene sky of winter, is a very remarkable circumstance. This has been again and again proved by philosophers, who have been especially engaged in observing the phenomenon of atmospheric electricity, but who appear to give it a less relative value.

Storms.

Mr. Quitman has collected tables of observation made during extraordinary circumstances, such as in times of snows, rains, and fogs. He finds that under certain conditions, a powerful electric atmosphere obtains at the *approach* of a rain storm, and after a rain storm, which is sometimes positive and sometimes negative. The electric intensity observed during fogs has a mean, the same as that obtained during snows, and is not much influenced by the time of season. The value of electricity observed during a tranquil rain, differs very little from the mean taken in the course of the whole year. The electricity of the air estimated at an elevation always the same, suffers a *diurnal variation*, which generally shows two *maxima* and two *minima;* and these are displaced according to the different epochs of the year. The first happens before 8 o'clock in the morning in the summer, and at about 10 A. M. in the winter. The second maximum is after 9 P. M. in the summer, and about 6 P. M. in winter. The day minimum is found to be about 3 P. M. in summer, but near to 1 P. M. in winter. The night minimum is as yet not so exactly obtained.

Observations accurately taken at all even hours Greenwich

mean time, and that unceasingly for three years in succession, — during the nights as well as days, — shows that the tension of atmospheric electricity is at its minimum at 2 A. M. Setting out, then, from this hour, and we find the tension increases more rapidly, so that its value at 8 A. M. becomes almost double of that at 6 A. M.; but from this hour the increase becomes more gradual again until 10 A. M., the period of the first or morning maximum. Now, again setting out from this last-named hour, the tension declines gradually until 4 P. M., a period at which its value is only slightly superior to that of 8 A. M. This second minimum is called by the French philosopher De la Rive the *diurnal minimum*, to distinguish it from the *nocturnal minimum*, which takes place at 2 o'clock in the morning. After that hour (4 P. M.) the tension increases rapidly until 8 P. M., and after a slight further rise until 10 P. M., — the period of the principal or evening maximum, — when the ascending march of the electric tension is terminated. The evening maximum is very notably superior to that of the morning, or say at about 10 o'clock. Between 10 in the evening and midnight, the tension of atmospheric electricity is decreased almost to the value of the diurnal minimum. It is occasionally observed on the same day that where the instruments mark 150° to 200° at the morning maximum, it runs down during the day so as to show only 3° to 4° at the afternoon minimum; but it usually happens that variations so great are immediately followed by storms.

We find that the air under a perfectly clear and serene sky, and when there is no storm within two or three hundred miles of us, is constantly, but moderately, positive; but this is not always uniformly distributed through all the strata of the atmosphere. It is found more nearly of the same intensity in a given horizontal stratum, but uniformly stronger in the upper strata, and stronger still in the ratio as we rise through the successive strata. But at the lowest stratum, i. e., at the surface of the ground where the air and earth unite, the electricity of the air is *null*. In the open country it does not commence to be sensible to most delicate instruments until about a yard or two above the ground. Where there are large trees, buildings, or

other elevated bodies, the evidence of its lowest positive pressure is to be sought still higher; i. e., more elevated from the ground.

The air and the earth are believed to be, as a whole, charged with different electricities, which are continually tending to recombine, and are perpetually doing so, by varied degrees, in the lower strata of the air, some directly by the dry land, but much more through good conducting bodies that are upon the surface of the earth. This is because our globe is *magnetic*, and charged with negative electricity (magnetic ?), although constantly uniting with the positive of the air; so that over all the surface of our earth, for a very few feet deep, the air is found at a near balance, i. e., neither positive nor negative, and the needle of the electrometer is here almost constantly at zero.

Now, we see that if each drop of rain, or each flake of snow, is of the same kind of electricity with which the globules of the clouds were charged, and of which they had indeed served to form a part, — the whole even, by their agglomeration, — it is easy to conceive how there is an electric change brought about with every fall of rain, hail, or snow, since this is carried onward with them in their fall. Each drop of rain, and each flake of snow, is doing a work that not only causes the electrometer and the barometer to fluctuate, but also causes joints, nerves, and bones to feel and confess their united power. Says De la Rive, wherever it rains there is a region of country, or sea, that for the time is charged with positive electricity; that this region is completely surrounded by a zone on all its border, but entirely outside the rain and storm, that is, charged with the *negative electricity*. Suppose there is rain falling at a very great distance from the place of observation, but which is approaching, and then soon arrives there under the action of the wind, and then passes onward and over without ceasing to fall, until all is passed. In that case, the following is the order in which it occurs, i. e., as the storm clouds approach and pass away: —

1. When the rain is very distant, the instruments indicate positive electricity in the air, as they do almost always, and even this with some considerable degree of tension.

2. When the rain has approached within a certain distance, we find a *strong negative electricity;* and this not unfrequently produces sparks to the fixed conductor.

3. When the rain has reached the place of observation, a great quantity of positive electricity has rapidly come, as found again indicated.

4. When the rain has passed over and gone, we now have again a strong negative tension; but this for a very short time.

5. Finally, when the rain is sufficiently distant, so that the zone also has passed off with it, the atmosphere returns to its habitual equilibrium or mean; i. e., for the time of clear weather; of moderately positive electric tension. Therefore we can recognize in this a law of three marked electric changes. First, that at the approach of the storm, which is *negative.* Second, that which prevails during the storm and fall of the rain or snow, which is *positive.* Third, that which follows close on its departure, which is again *negative;* but that this latter is not so marked, or of so long duration; and this is again succeeded, as we have said, by that clear, serene sky that we call a *pure atmosphere*, possessing its full quantum of natural electricity, and no more. It is believed that negative or neutral rains do not come; that negative clouds do not exist. When the air is perfectly pure, the upper stratum of it is electrized positively in respect to the lower strata, while at the same time the surface of the earth is nearly neutral, and hence the electricity of the atmosphere must increase as we rise. To test or prove this, M. Becquerel ingeniously employed arrows shot from a cross-bow. To the arrow, when shot, was attached a fine silk thread neatly covered with tinsel, the other end of which communicated with an electroscope. He thus fairly and beautifully demonstrated the increased ratio of positive electricity in the atmosphere to be in direct proportion to the height in the air. He made this experiment at the Great St. Bernard, in Switzerland, and upon the top of one of those elevated plateaus near the Hospice.

But our space allows us merely to allude to all these highly interesting and instructive observations, made by the aid of the telling *Electrometer* for testing atmospheric electricity, as to

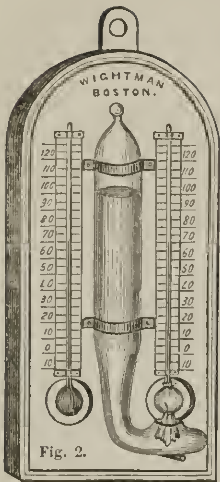


Fig. 2.

quantity and intensity; by the *Barometer* and other instruments, for ascertaining the atmospheric density, *humidity*, ozone, &c.; or by the *Thermometer*, for its heat and cold. Such like meteorological observations made with much care, and that by all these present helps for testing and comparing the normal and abnormal electricities, and other states of the atmosphere, together with another class of observations for determining the *magnetic variation* in the earth, — simultaneously made on the land and on the sea, on different continents, in the extreme north and extreme south, as well as at the equator, — are to any philosophic, or logical mind, full of significance, as relating to health and disease, life and death, in the great human family.

We will only remark very briefly, that with regard to the real electric state of the atmosphere, and of the terrestrial globe, philosophers have long differed. But of late, Arago and De la Rive have concluded and do now assume, that our globe possesses, at least on its solid surface, an excess of accumulated negative electricity, and that this is the same with bodies on its surface; that the atmosphere itself, on the whole, is positively electrized, and arises from the same source as the negative of the globe. They noticed that when the most highly charged storm clouds approach mountains, the clouds go towards them with a rush, and with that quickness in proportion as the summit of the mountains have the more marked negative tension. They are then observed to linger, and adhere as it were to the mountain, as if indifferent or slow conductors, yielding successively either electricity. This, we notice, is observed only in respect to *static*, electricity. If, now, we consult the galvanometer, we find phenomena for study in *dynamic* electricity. For when the cloud approaches the mountain, and as it commences to pass, the instrument gives indications of *ascending* currents, because the electricity of the ground is found to be attracted towards the

clouds; and very frequently have we witnessed the clouds of dust and trash violently raised, not by the wind only, but by this force. And all this is reversed, as soon as the rain pours down, for it brings with it the superabundance of positive electricity from the clouds. At each clap of thunder, or rather at each flash of lightning, the needle of the galvanometer is agitated, and even driven back with force against its stops. At other times the magnetic state of the needle is found to be permanently altered.

Difference between Electricity and Magnetism.

Dr. J. C. Atkinson, of England, thinks that magnetism and electricity are not identical, and differ in the *effects* which they produce upon the weather and climate. He says,—

Magnetism of the earth is a state of continual and restless fluctuation, and that its changes from moment to moment *are strictly simultaneous* at every point where observations of this nature have been made. It is my impression that cold is an effect of magnetic influence, as solar heat in the atmosphere is an effect of electric action; and I conclude that the vital principle of temperature is the result of the combined agency of these two forces, variously modified, according to seasons and latitudes of the several places. The range of the barometer gradually increases towards the north pole. The rise of the barometer mercury may be observed in this country during the prevalence of northern winds, conveying as they do magnetic currents, till at last it reaches to two or three inches. On the contrary, between the tropics the variations of the barometer are exceedingly small, whilst winds from the southward, in temperate latitudes, if the electric current or wind is continued for any length of time, will cause a tendency in the mercury of the barometer to fall.

The winds are more powerful in the production of weather than would appear at first sight; and although the moon was always supposed to exercise great control over the weather, yet it is strange that both Drs. Herschel and Clarke, great observers

of the heavens, state in the weather tables, as a set-off, I conjecture, to her influence,—"If the particular change of the moon, full or new, takes place when the wind is so and so, it will be fine for the ensuing week; and the reverse if it is not." I ask, Does this prove the dominion of the moon over the winds, or the contrary?

Magnetism.	*Electricity.*
1. The intensity of the magnetic force in different parts of the earth is according to the distance from the poles.	1. The intensity of electric force is greatest at the tropics, and diminishes as it approaches the poles.
2. The frigid zone, where magnetism is in the greatest intensity, enjoys an atmospheric calm which is unknown in temperate regions; it has no storms, no hail, and scarcely a tempest.	2. The most vivid lightning and the loudest thunder are peculiar to the tropics; here vegetation is vigorous, and active at all seasons.
3. The splendor of the aurora borealis, reflected by the snow, dispels the darkness of the polar night, but is not accompanied with danger.	3. Igneous and fiery meteors, fire balls, and lightning are the peculiar electrical phenomena of the tropics.
4. Magnetism suspends the decomposition of vegetable and animal matter.	4. Electricity assists decomposition in all vegetable and animal substances.
5. In northern latitudes the mercury of the barometer always stands high; in the temperate latitudes it is liable to frequent variations.	5. The mercury of the barometer is always low in the torrid zone, and varies but little during the changes of weather.
6. Magnetism has been known to produce sedative action on the human frame, when applied under certain conditions, causing repose, if not sleep.	6. Electricity is of an exciting character, increasing the circulation of the blood, and rousing paralytic functions of the nervous centres.

7. The northern currents of atmosphere, accompanied as they are with magnetism, have the power of expansive action on the mercurial column of the barometer, wherever it may be placed, either in a warm room, or in the open air.	7. The southern currents of the atmosphere, accompanied with free electricity, cause a fall of the mercurial column under any circumstance of position of the barometer.
8. Snow from the north-west wind has been found to contain more oxygen than rain or river water, and more carbon.	8. Electricity causes the rain to descend with less oxygen than snow water; and less carbon also.
9. The magnetic intensity of the earth is indicated by needles suspended vertically; and in sailing from England towards the north pole, it is seen that the needle dips, or inclines more and more, with the increase of latitude, till at a certain point it remains exactly *perpendicular*, with its south pole downwards.	9. In sailing towards the equator, with a magnetic needle suspended in the like manner, the inclination or dip gradually decreases, until the needle rests in a perfectly horizontal position.

The above are some of the reasons which have induced me to think that magnetism and electricity are not strictly identical, their operations being as distinct as heat and cold; and I have therefore come to an analysis of the influence of the winds, and a theory to establish something of a definite character. Winds are not decisive as to their influence on health, when continually changing; that is, not remaining in any fixed quarter for two or three hours at least. Winds have been known to blow from different currents, as spoken of before. Mr. Green, the *aeronaut*, in his celebrated aerial trip from Vauxhall Gardens to Nassau, in Germany, frequently availed himself of the different currents of air at different altitudes, by raising and lowering his balloon; and in this way he regulated his passage across the Channel, opposite Dover. The highest elevation

attained by him, during his voyage of nearly five hundred miles, (British,) was twelve thousand feet above the level of the sea. At the highest point of elevation, it appears from the account that there was less circulation of air than at any point below it.

On the earth's surface, then, we have frequent changes of wind, and this more particularly in temperate latitudes, or climates; and hence there are frequent alterations in the atmosphere as regards both temperature and electro-magnetism. Sometimes a wind, well known for its peculiarly mild character, assumes so different a nature as to be mistaken for a wind from altogether another quarter of the globe. This arises from various winds supplying one current of air. For instance, we have a south-west wind of some velocity, of a stormy nature, and highly charged with electricity. Suppose, then, this wind to have a parallel breadth of any number of miles, and then to be supplied by north-east and north-west winds; of course, under such an influence, we shall have a great reduction of the temperature, and other qualities somewhat reversed, for a time, at least.

A north-east wind, on the other hand, will frequently have its real nature or character altered, owing to rapid changes of aerial currents during stormy or thundery weather; and this happens more particularly when the observer is situated on the external edge, as it were, of a parallel but contrary current of wind, which varies in diameter, at various seasons, from ten to one hundred miles; and hence an unusual temperature is given to it. In the centre, however, of the said parallel current you have the true quality unmodified.

We now come to the question of health and disease, under the operation of the several winds. The north wind (I here refer to the magnetic north) has a different influence on different constitutions and ages. The temperature of this wind of course varies, as has been before intimated, according to the seasons; but its general characteristics are always alike. This wind is usually unattended by hail, or even snow, although if a few points to the eastward it will often be followed, in the winter season, by the above phenomena.

Electric Relations of the Earth to its Atmosphere.

Professor Faraday introduced and expounded, at a lecture before the Royal Institute, the hypothesis of M. Pelletier respecting the electrical relations of the earth and its atmosphere to the "planetary space" in which it moves. The method by which the electricity of the atmosphere was determined by MM. Pelletier and Quitelet was shown to correspond very nearly with those of Becquerel and De la Rive.

The instrument employed by these investigators was a brass globe, placed on a thin metallic stem, to which is affixed a delicate galvanometer needle, which indicates by a minute measurement in degrees, the amount of electricity obtained.* This instrument was used on the summits of high buildings, where it was above every surrounding object. The method formerly adopted was to employ for this purpose a long metallic rod, furnished with points which projected into the air, to be examined. M. Pelletier's mode gives the quantity, and the kind, with great certainty; while the old method furnishes uncertain and often contradictory results. Dr. Faraday illustrated, by enlarged models, the influence of various degrees of elevation on M. Pelletier's electrometer; at the same time showing that no changes take place from variation of position, when the instrument is moved horizontally, and that thus, throughout each stratum, the electricity of the air is the same. It is the vertical elevation, or depression, which produces. a marked difference. The results obtained by M. Pelletier are, —

1. That the electricity of the air increases directly with the distance from the surface of the earth — a fact of great importance, as it influences the determination of the question whether the electricity of the earth be derived from planetary space, as Pelletier affirms, or whether, as Professor Faraday thinks, it be the result of various processes taking place on the surface of the earth.

2. The measure of divergence of the electrometer being

* Med. Gazette, February, 1850, p. 255.

the measure of force, it was found from a series of daily observations, extending over a period of five years, (1844–8,) that the quantity of electricity at the same place, undergoes a regular increase and decrease in certain months of the year; that, contrary to general belief, the quantity of electricity is at its *maximum* in winter, and undergoes a decrease until it finds its *minimum* in June, and then again rises to its maximum in the succeeding January.

The subjoined table represents the numerical results; and from this it will be seen that at the same level the quantity of electricity in the atmosphere is *twelve times as great* in the cold month of January as in the hot month of June.

Average of Five Years—1844 to 1849.

Months.		Quantity of Electricity.
January,	*maximum*,	605
February,	"	378
March,	"	200
April,	"	141
May,	"	84
June,	*minimum*,	47
July,	"	49
August,	"	62
September,	"	70
October,	"	131
November,	"	209
December,	"	507

3. *The Influence of the State of the Sky.*—From the results under this head, it is made evident that the highest degree of electricity is not found in cloudy weather, but rather in the clear, serene sky; i. e., at a time when the atmosphere is free from clouds. Thus, for the whole year, the proportioned *quantity* may be represented—cloudy 186, clear 273. In reference to the monthly variations, as influenced by the state of the sky, it was found that in January, the maximum month of the year, the proportionate quantities are, cloudy 268, clear 1133. Only

one exception, for an equal number of cloudy and clear days, was met with to this rule, viz., in July; the electricity on the cloudy days was 41, on the clear days 35.

4. As regards fog, snow, and rain, it was observed that the amount of electricity was the same during the two former states of weather, and was double that observed during rainy weather — the latter corresponding to the minimum of the annual electricity, the former to the maximum of the year.

5. *As to the Kind of Electricity in the Air.* — It was noted that during a period of five years, only twenty-five observations gave evidence of resinous or negative electricity; the rest consisting of eighteen hundred observations, which indicated vitreous or positive electricity. The negative observations were all recorded after storm or rain, or some other great meteorological change. The normally electrical state of the atmosphere may therefore be considered as *positive*.

6. *Wind.* — It was observed that when the wind was E. S. E., or S. E., two maxima were regularly formed, and two minima when at W. S. W., and that these corresponded with the other variations which have been mentioned.

7. The diurnal variations were recorded during the same period of five years, from six o'clock in the morning until nine at night. The degrees of divergence showed that there were two maxima and two minima daily. The maxima were at 8 A. M., and from 8 to 9 P. M., in opposite periods to the magnetic maxima. One minimum was from 2 to 4 P. M.; the other, probably, during the early morning hours.

All these great and regular phenomena of the atmospheric electricity, Dr. Faraday observed, are phenomena of *static electricity*, while the thunder storm, the St. Elmo light, &c., &c., are exceptional instances of *current* or *dynamic electricity;* not necessarily, however, requiring clouds for its concentration or evolution.

The professor concluded by expressing his dissent from the theory of M. Quetelet, that the electricity of the earth was negative, and that of planetary space was positive. According to this theory, the only true electricity is what we call negative;

i. e., that kind produced by the friction of resinous substances, while the positive electricity is merely the *absence* or negation of electricity. It thus reverses all our common notions of electrical science.

Dr. Faraday observed, that while admitting to the very fullest extent the value of the observations and investigations of MM. Pelletier and Quetelet, which he had brought before his audience, he nevertheless could not receive the hypothesis they had framed thereon. These researches on the electricity of the air, are not only interesting in a meteorological respect, but intensely so in a physiological and pathological point of view. While they account for storms in cloudless skies, and for the occurrence of severe storms during the winter, or in very cold latitudes, as at Cape Horn, for instance, (the Cape of Storms,) *they tend to throw light upon the exacerbations of disease* at different hours of the day, as well as on the increase and decrease of epidemic and other diseases in different months of the year. Such remarkable changes in the electricity of the atmosphere cannot go on without affecting the static electricity of the human frame. According to the researches of Casper, of Berlin, the greater number of deaths from disease take place at the early hours in the morning, when the quantity of electricity in the air is reaching its *minimum.* Is this merely a coincidence, or is there some yet undiscovered connection between the cessation of life and the electrical state of the medium in which the human body is placed?

Weather Observations.

The British Board of Trade has seen fit to publish, for the use of seafaring men, general maxims of weather, because the *color* of the sky *at particular times* affords, with the barometer, good collateral weather prognosis. Not only does the "rosy sunset" presage fair weather, and "a ruddy sunrise" bad weather, but there are other tints which bespeak with equal clearness and accuracy. A *bright*-yellow sky *in the evening* indicates wind; a *pale*-yellow, wet; a neutral gray color constitutes a favorable

sign in the evening, but an unfavorable sign if in the morning. The form and appearance of the clouds themselves are full of significance. If their forms are generally soft, undefined, and feathery, then will the weather be fine. If their edges appear hard, sharp, and well defined, it will be foul. Besides, generally speaking, any *unusual* hues, as the deep, dark, or very gay, betoken wind, or some falling weather, (rain, snow, hail, &c.;) while the more moderate and delicate tints bespeak fair weather.

Lightning.

M. Arago says there are three kinds of lightnings — the *forked*, the *sheet*, and the *spherical*. The forked lightnings are in slender white or bluish streaks, that are zigzag or crinkled, and sometimes divided or forked. This is the most common kind. The sheet lightning, he says, is uniformly of a dull red appearance. The spherical are the same as *thunderbolts*, which descend more seldom and slowly to the earth, according to a law of their own, rendering lightning rods, as for them, useless. But there are also recognized two *kinds* of electricity in the atmosphere, so that the one or the other is always prevailing and affecting the health of mankind according to the weather; or, rather, according to the prevalence of this or that kind of electricity, so is the weather. The one is vitreous or positive, the other is called resinous or negative. These two forms of electricity are produced in the atmosphere itself from various causes — chiefly from evaporation, more also from condensation and separation of its moisture; from vegetation, from combustion, and from friction. This latter arises from large masses of air, moving in contrary directions, and thus encountering or chafing one another. The friction on the edges of such currents develops free electricity, which is more especially active when these moving masses of air, arising from different quarters and at different altitudes, differ also in their respective degrees of moisture and temperature. The cold develops negative electricity, the warm the positive electricity. Thunder storms, then, are the result of the approximation of vast quan-

tities of opposite electricities, positive and negative, or plus in one and minus in the other, according to Franklin. There is usually thunder with the lightning, but there are lightnings without thunder, and so are there thunders without lightning. There are actual thunderbolts found in several parts of our own country, and in other parts of the globe — ponderable, tangible bodies; one of the most marvellous specimens of which, I think, is to be seen in the cabinet of Yale College in New Haven.

Safety from Lightning.

It is often asked of us how to avoid the danger by lightning. We usually advise on general principles, rather than give specific directions. Persons who are perspiring copiously, or are wet, are, on the whole, more exposed to danger by lightning than others whose skin and clothing are generally dry. The dress is truly important; but the casting away from one's person, and every way avoiding the locality of metals, as coin, scissors, pocket knife, or the proximity to the butt of a tree, or chimney, or iron, is also important. It is best not to stand in the doorway, nor yet by a window, particularly if it is open, as the warm air of the house acts as a conductor, and in that case attracts the lightning. Ladies dressed in silk, if with no jewelry, having a dry skin and clothing, are the least exposed of all persons. After having divested one's self of coin, jewelry, &c., then the next best thing to be done is to seek a position in the middle of the room, on a bed, or *any where away from conductors; also avoiding the range between two conductors.* Dr. Franklin's advice was to avoid the fireplace. I say avoid, also, the proximity to stove or gas pipes, water pipes, and lightning rods. Such are prudent precautions, under Providence, and it is but wise and important to observe them; yet we must bear in mind, that there is no absolute safety, as lightning will not *always* respect silk and glass, nor human wisdom. A person may be struck with lightning and yet not be killed; they may receive only wounds or laceration, or these with death. The victim may bear the traces of dreadful burns, or singed hair,

but these are the *indirect* effects of lightning. *Its direct action* on the human body is a shock, more or less great, and this by exhausting the human nerve-batteries more or less; when complete, it leaves the body a mass of disorganized matter, and instantaneous death is the consequence. When wounds are produced they are usually in some internal vascular portion, and from which there is an instantaneous and frightful effusion of blood, &c., and hence death in these cases is also necessarily immediate. In these cases there is an utter disorganization that admits of the immediate and most revolting putrefaction. But lightning now and then causes death by a simple shock, that appears to have been only just sufficient to exhaust the nerve-batteries, or modify them sufficiently to destroy life; and here, it is said, the bodies do not readily decay. Indeed, some persons may die from lightning only striking *near* them.

From the remotest ages, we learn that the various tribes and nations of men have devised ways and means as widely different as curious, to protect themselves from thunder and lightning. Among the more civilized nations, there was for centuries a resort to the ringing of large bells, because it was believed that this was capable of paralyzing the effects. This, indeed, was one of the greatest uses bells were first put to; hence are found on old bells in Europe the following inscription: *Vivos voco, mortuos plango, fulgura frango.*

Another *freak* of lightning is mentioned by M. Arago as a curious fact — that lightning has been known to strike, penetrate, and demolish powder magazines, and there upsetting and scattering the powder in all directions, and yet not set it on fire! This fact, though rare, — for the setting it on fire and producing an explosion is by far the more usual result, — illustrates *the law of damage to man;* for electricity by friction, as in that case of lightning, never burns, nor even explodes gunpowder, if it meets no hinderance; but rather follows an ample conductor. In this case it is too quick to fire, burn, or disorganize. It can be demonstrated that electricity or lightning explodes the powder; burns, tears, or disorganizes to destruction, only when it encounters in its route a given degree of resistance that actually delays its velocity.

A very rare, but instructive case, among the *accidents by lightning*, is given, which is designated by De la Rive, as "*struck by a return-shock.*" He says persons or animals may be struck by lightning at a great distance from a storm cloud. This is an effect of induction on a grand scale, yet of easy explanation. Whenever a storm cloud that is powerfully electrized approaches so that the person is situated within its sphere of activity, the natural electricity of this person is decomposed by actual induction. The molecules of the living body is naturally bipolar; now, that in the person of the contrary name to the electricity of the clouds is attracted to the cloud, while that of the same name in the person is repelled to the ground; the person therefore is found to be in a highly electrical state, but contrary to that of the cloud. But, if now the cloud happens to discharge itself from any point, say to a tree, or to a rock, and thus losing on a sudden a large portion of its surcharge of electricity, it is no longer able to retain the person who is beneath it in an electric state, contrary to that which now the cloud itself possesses. In fact, the electricity of the person's body was simultaneously and suddenly discharged to the earth, the same instant that the cloud discharged itself to the rock. The electric change which may thus result, may be sufficiently powerful to cause death, without leaving any visible trace of alteration, or the least mark of injury whatever, on or in the dead body. Besides, there are very many persons who have so little nerve power, or what may be termed *power of endurance*, that it requires but a slight, quick electric change to put out their taper of vitality, and, therefore, although in passing health, it might bring to them instant death, without leaving a trace behind.

Effects of Lightning on the human Organism.

How lightning kills, is a question that M. Brown-Sequard has studied much, and now assumes to answer. Some philosophers are every now and then extending their researches in the direction of *embryotic* life; but here we observe a scrutinizing philosopher and physiologist devoting his persevering attention to

the various phenomena of *death*. From his extended researches in this direction, Dr. Sequard lays down the proposition that "every cause of excitement in the nerves and muscles must disturb their forces, and therefore acts in such a manner as to diminish the quantity (which means the power) of those forces that are found in the individual from moment to moment, and that in the exact proportion as this excitement is the more or less energetic." Hence he concludes, that lightning kills by exhausting the whole quantity of the dynamic forces, that are at that moment possessed by the animal economy; and therefore life must cease, because the vital acts cannot be maintained one moment without them. He supposes death to take place by asphyxia, or, as we may say, *by absolute collapse;* as after the extremely violent contraction of all the respiratory muscles, which is found to be produced at the instant of being struck by the electric shock, so that there is no spring left, no rebound of the natural electric polarity of the molecular structure of the nerves and muscles, for they are in fact totally exhausted and disorganized. This he illustrates by killing animals with the discharge of a powerful battery. He has found that if the discharge is directed through the diaphragm, it kills quicker and more surely than when directed through the head of the animal. It is also noticed that an animal so killed always opens its mouth in a few moments after the death stroke, as if gasping for breath, as it probably is; but there being no responsive motion of the thorax, this is scarcely repeated, and soon ceases altogether. The post mortem, shows a fluid state of the blood, and there is a general state of congestion in the liver, spleen, and cerebral vessels; while the lungs and the cavities of the heart are nearly empty! This is very different from that state of the heart found after death by chloroform, for there the left ventricle is enormously distended. It would seem from this, that after the diaphragm and heart gave their last great contraction under the stimulus of the lightning, there was no sort of dilating property left; that the body is now only a disorganized mass, ready for immediate putrefaction.

M. Boudin, a French philosopher who has made this particular

department of nature's rare phenomena the object of his protracted study, says there are three kinds of results produced on man by lightning: first, it can *cure* preëxisting affections; second, it can *produce* wounds and infirmities; third, it can *cause* death. He enumerates in his work, under the first order, as "occasional recoveries by thunder and lightning," amaurosis, deafness, roaring in the ears, paralysis, and rheumatism. He speaks of the phenomena as "unforeseen, various, appearing as opposites, involved in contrasts, and mysterious." He quotes the case of a man that was struck by lightning who manifested no appearance of life until an hour and a quarter afterwards, yet he entirely recovered his consciousness together with his undiminished intellect; but, strange to say, his sight was totally destroyed. His skin and muscular sensations were obtused, and his movements were very difficult. The various parts of his body no longer seemed to belong to him. But his taste, hearing, and smell were exquisitely augmented. His rest was poor, and his days were heavy. The general prostration was great, and this was attended with headache. Indeed, there was a veritable resolution of the general muscular forces; and the body in a degree was only a dead mass, mostly obeying the laws of gravity. He was burned and bruised, and these did not heal. Besides, he suffered from a succession of cramps. At the end of a month the pulse was low, frequent, and irregular. Galvanism was then here applied near the wounds and burns, as also an up-running current upon the spine, which caused immediate relief. He was soon observed to be improving. The galvanizing was continued from time to time, and, together with quinine, leeches, baths, and good nursing he gradually bettered until it worked a complete cure. But it was four months before the galvanic treatment was discontinued.

Professor Olmsted, of New Haven, speaks of a man by the name of Samuel Leffers, who, having been blind for years, was restored to sight by a flash of lightning. M. Boudin mentions that somewhere in France, in August, 1846, there was a group of laborers struck by a bolt of lightning, when four were killed, and six were badly wounded. One of these men had on a goat-

skin coat, and on his body there were found the most frightful mutilations; and in three hours after, his body was as rigid as a mass of stone. So in some cases where persons have been killed by lightning, we may find the muscles rigid as if solid, while others are as remarkably flaccid. The blood is usually, if not always, as fluid as during life, or even more so, but probably never coagulated. Putrefaction commences most frequently at once, and goes on shockingly. But there are cases recorded where the corpse was found sound after a great length of time, as if petrified, or possessing some antiseptic property or state, that resists all decomposition. But mutilations very rarely occur in the human organism, while animals are very frequently broken and torn asunder. Dr. Boudin states, that out of several hundred persons killed by lightning, he found only six bodies that were mutilated; of these there were four of partial or total tearing out of the tongue. The great prominence of the eyeball is often produced; sometimes there is a small hole in the skull, as if shot. These different solutions of continuity may mark the route of the lightning in that individual case, but as yet we know of no law to determine it, other than circumstances—such as position of the body at the moment; the greater or less conductibility of the body, or of the clothing; the insulation, approximation, or line of direction for conducting the electric fluid *towards* him, or *from* him, in a direct route between the point where the bolt leaves its conductor to skip to a better conductor.

Effects of Atmospheric Electricity on the human Organism.

The human organism is decidedly affected by atmospheric electricity, from the slighter changes in the electric state of the air, as well as by *bolts of lightning*. Healthy individuals even feel the exhilaration of a serene and positive atmosphere, as also an increased heaviness and oppression at the opposite state of the air. If the weather be stormy, and the air is surcharged either positively or negatively, or is suddenly changed from the one to the other state, then do we find the neuralgic, the rheumatic,

and all invalids feel pains and depressions. When the negative lower stratum of air, which is near the surface of the earth, obtains also in the higher strata for a while, as before a storm, and sometimes just after, then it is that the rheumatisms ache, and the neuralgias give their ugly twinges; the frail feel a peculiar fatigue and are irritable, or are perhaps drowsy. In the extremely sick, the dyspnœa of emphysema and of heart disease are worse; complicated chronic rheumatism is awaked, paroxysms of fever anticipate their accustomed hour; in severe acute diseases the symptoms are doubly alarming; while in fatal cases, death will arrive earlier in unsettled and stormy weather than would have been had the atmosphere been serene.

It is highly probable that this state of humid and negative air induces a large and sudden precipitation of the native electricity of the living body to the earth, which disturbs the animal electricity, changing the state of fibres, nerves, and organs; and this perturbates the regular functions that are so entirely depending upon the normal nervo-electric equilibrium.

One indirect effect of atmospheric electricity on the health of man is through ozone, which indeed is but a modification of the oxygen of the air from an electrical operation. The hypothesis of Dr. Boeckel makes a direct ratio between the diminution of ozone in the atmosphere at a given season, and the prevalence of cholera and of miasmatic diseases, as he believes he has demonstrated it at Berne and Strasburg.

Dr. Casper, of Berlin, has made extensive observations, which result thus: —

1. The greatest number of *births* occur between nine o'clock in the evening and six in the morning; while the smallest number occur between nine o'clock in the morning and six in the evening.

2. The pains of labor commence most frequently between twelve o'clock at night and three o'clock in the morning; least frequently from six to nine in the morning.

3. The influence of night is more marked with respect to the commencement of labor pains than with respect to complete delivery.

4. Among those births in which the pains commenced by day, the greater number were male children, and *vice versa*.

5. On an average, delivery was more protracted when the pains commenced by day than by night.

6. The preponderance of nocturnal over diurnal births is more striking in respect to children born dead, than in respect to those born living.

7. The *maximum* mortality occurs in the hours before noon, and the *minimum* mortality in the hours before midnight.

8. Individually regarded, the ratio of deaths from inflammations, phthisis, and pulmonary hemorrhage is greater in the afternoon; from fevers and exanthemata, just before midnight; from cerebral apoplexy, during the day; and from disease of the nervous system in general, in the hours which immediately follow midnight.

Dr. Thomas Laycock, when remarking upon the great prevalence, during last autumn, of diseases of the nervous system, makes the inquiry, whether the cause of this could arise from the nutritive functions having been less active.* Besides epigastric or hypochondriac neuralgia, he alludes to cases of quotidian intermittent tic-douloureux, or brow ague. In one case the painful ramifications of the upper cervical nerves were traced out by the patient; in another, the pain was limited to the infra-orbital branch of the fifth; and in other cases the paroxysms were accompanied by violent headache. Now, what is remarkable in these cases is this: —

The greater proportion of them, indeed, all, I think, without an exception, began or ended about the same hour of the day. There were two paroxysmal hours in the case of the man who had been working in low grounds, and who had been affected for two or three weeks; the paroxysms began regularly at 4 o'clock P. M., and continued to 4 o'clock A. M. He then got ease, and went to sleep. And this was the case with several others. But the man with neuralgia of the supra-orbital nerve began to suffer at 8 or 9 o'clock A. M., and the paroxysm con-

* Braithewaite's Retrospect, No. 15, p. 28.

tinued until 8 or 9 o'clock P. M. Of course there is a reason why these hours are selected for the commencement and termination of the paroxysm. What then can it be?

In the first place, we find that the atmospheric tides attain their maximum and minimum at certain hours of the day, for there are tides in the circumambient atmosphere, as well as in the circumambient ocean; and therewith there are also changes in the electricity of the air and the magnetism of the earth. From 8 to 10 o'clock A. M. and P. M., the barometer is at its maximum height; the electric tension is at its maximum too; and there is also the greatest maximum variation east of the magnetic needle at the same hours. From 4 to 5 o'clock A. M. and P. M., the barometer is at minimum; and so is also the electric tension. It ought to be borne in mind, that there are other diseases which have a relation to these meteoric hours, but *principally those of the nervous system;* as those whose onset is dependent upon some predisposing condition of the nervous system. The respiratory movements, and of course the activity of the circulation, are in connection also with these hours. About 4 or 5 o'clock in the morning, with a minimum temperature, a minimum electric tension, and minimum height of the barometer, there is also a minimum consumption of oxygen. Further, I have ascertained by frequent inquiry that sleep to the nervous, generally comes on about that hour, after a feverish restless night; and, what is more remarkable, the statistics of deaths in the State show, that the mortal changes are in the proportion of three to two; that the last sleep — the sleep of death — will occur at that hour. Now, all these coincidences cannot be accidental; and as the operation of natural laws is as unerring as that of the most exquisite machinery, due investigation and inquiry only are requisite to lay bare this whole mystery.

Dr. Pallas, chief physician of the French army in Africa, asserts that the greater number of diseases, particularly the "neuroses," are due to the influence of widely deviating electricity; the principal sources of which are thunder clouds and marshy soils. By their geographical constitution, and their effects upon the human organism, *marshes* (says M. Pallas)

present the closest analogy to the galvanic battery. Their deleterious effects are formidable in exact proportion with the quantity of saline or organic matter contained in the waters; and observation proves that diseases developed by the influence of marshy emanations are, at first, of a nervous nature; hence one of the methods which will be most efficient in preventing intermittent fever and neuroses, must be the *electrical isolation* of chairs, beds, and tables from the earth by glass supporters.

Electric Changes the Cause of Epidemic Diseases.

In 1849, M. Andraud made daily observations and experiments in and about Paris during the cholera there, which show a striking coincidence between the amount of atmospheric electricity and the virulence of the epidemic. In a letter to the President of the French Academy, dated June 10, 1849, he says, —

The machine I have used for my daily observations is rather powerful. In ordinary weather it gives, after two or three turns of the wheel, brilliant sparks of five or six centimetres. I have noticed that since the invasion of the epidemic I have not been able to produce on any one occasion the same effect. During the months of April and May, the sparks, obtained with great trouble, have never exceeded two or three centimetres, and their variations accorded very nearly with the statistic variations of the cholera. This was already for me a strong presumption that I was on the trace of the important fact I was endeavoring to find. Nevertheless, I was not yet convinced, because one might attribute the fact to the moisture of the air, or to the irregularities of the electric machine. Thus I waited with impatience the arrival of fine weather with heat, to continue my observations with more certainty. At last fine weather came, and to my astonishment, the machine, though often consulted, was far from showing, as it ought, an augmentation of electricity, but gave signs less and less sensible to such a degree, that during the days of the 4th, 5th, and 6th of June, it was impossible to obtain any thing but slight cracklings without sparks. On

the 7th, the machine remained quite dumb. This new decrease of the electric fluid has perfectly accorded, as is only too well known, with the renewed violence of the cholera; for my part, I was not more alarmed than astonished; my conviction was complete. I saw only the consequence of the fact already supposed. It may be imagined with what anxiety, in these moments of the crisis, I consulted the machine, the sad and faithful interpreter of a great calamity. At last, on the morning of the 8th, some feeble sparks reappeared, and from hour to hour electric intensity increased. I felt with joy that the vivifying fluid was returning in the atmosphere. Towards evening a storm announced at Paris that the electricity had reëntered its domain; to my eyes it was the cholera disappearing with the cause which produced it. The next day (Saturday the 9th) I continued my observations: the machine then, at the least touch, rendered with facility most lively sparks. Now, it is stated that in the six days following the 8th of June, the mortality in Paris fell regularly from 667 to 355.

Another very curious circumstance is related by Dr. Kidd, of Limerick, Ireland, in the Medical Times of July of that year. While the epidemic was raging in that city, a large magnet, capable of sustaining seventy pounds, was watched daily. No variation took place in it. But on the appearance of the disease in Dublin, — one hundred miles east of Limerick, — the cholera being quite gone from the latter place, the magnet now suddenly lost nearly all its power.

Sir James Murray, M. D., who adopts Dr. Benjamin Franklin's theory of electricity, published a series of extensive investigations and experiments made by him, or under his auspices, some years since,* from which we make the following abstract from his own conclusions, and mostly in his own words: —

1. I consider, he says, that *the exciting cause* of epidemics, which is called *malaria*, is not "bad air" at all, as the name implies, but the result of disturbed electricity.

2. That marsh miasms, gases, or effluvia of vegeto-animal matters, or putrid emanations, are not, as is commonly supposed, the exciting causes of agues, or other diseases called malarious.

* These views are not wholly adopted by the author.

3. But I consider these noxious emanations are disturbed *electro-galvanic* currents and electric accumulations, — sometimes positive, sometimes negative, — causing a want of electrical equilibrium in human bodies.

4. That these electric agencies are untowardly excited or set free from soils of fens or marshes, drains and sewers, by the known effects of evaporation, chemical action, and infiltration of decomposing substances, and putrid deposits, or from foul waters, among minerals, ores, metals, and dissimilar strata of soils and subsoils, and also in wet lands, or during rainy seasons, after long-continued absorption by the earth of solar heat.

5. That as it is notorious that there are more insalubrious dry and high places in the Roman Campagna affected with malarious diseases, than wet and low situations. I consider that in such elevated and arid spots, long noted for insalubrity, there is emitted from the earth's surface an untoward emanation of electro-galvanism, with its concomitant lethal agent called *ozone*, set free by causes operating within the soils of that locality, either by the juxtaposition of strata of dissimilar materials, acting electrically upon each other, or by the infiltration of subterranean streams, or mineral waters, and by internal heat, and consequent liberation of steam — electricity; or by some other agents, acting upon materials contained in the ground, analogous to the manner in which we operate upon artificial substances in a galvanic apparatus.

6. That in some of the thousand ways in which galvanism is produced in the earth or air, its undue influence (under certain circumstances) disturbs the natural electricity of human beings, particularly when recumbent, in contact with the ground, or on beds, near the earth.

7. That this protracted or often repeated disturbance, either in the relative quantity of electricity itself, or in the due proportion of the positive or negative, (fluids,) alters the condition and functions of the human nerves, and probably the relative state of the particles, and the polar relations of the atoms, or corpuscular molecules, and at all events is capable of exciting or depressing the vital functions, and of acting chemically on the circulating animal fluids. This is obvious near rivers, and during east winds; the agency of passive or negative electricity, then, and there, inducing diseases of debility.

8. That these untoward galvanic agencies account more clearly for the specific cause, specific symptoms, and specific cures of some classes of complaints, such as intermittents, than the hitherto assumed action of *marsh miasmata*, which are supposed to be so various in their nature. In regions in which there are no fens or marshes, such as the Island of Ascension, &c., the agues incident to strangers are the same as where morasses are extensive. In both circumstances, the disorders occur at particular seasons, are confined to particular situations, and require particular and identical treatment.

9. That the doctrine of marsh miasms is untenable, because malarious diseases attributed to them are common where there are no marshes, and because domestic animals are in general perfectly healthy, whilst human beings

fall by thousands, which surely would not be the ease were noxious miasms inhaled into the lungs during respiration.

10. The immunity of lower animals seems to rise from the comparative density of their integuments, rendering them less liable than man to the influence of electric accumulations, galvanic currents, or the disturbance of the (natural) fluid in them by induction. The hairs or wool being wet at night, serve as pointed conductors, which diffuse or dissipate opposite electrical currents into the earth or air, and prevent their effects on the small brain and nerves of domestic animals.

11. That the general immunity of blacks (even of those who have lived long in our climate) from malarious diseases appears to prove that inspiration of malarious air by the lungs is not absolutely noxious, and that the cutaneous texture, oily secretions, and non-conducting varnish of their daily anointing and painting, render their skins less susceptible or more repulsive of electric agencies than the integuments of whites. The black color, as it absorbs heat sooner than white, may also make a difference in the electric conducting power. Even a black silk thread, or ribbon, or stocking, presents very different electrical phenomena from those of white twist or white fabrics of the same texture.

12. That this doctrine of electrical origin of malarious diseases enables us to approach much more nearly to salutary means of prevention, than the old theory of inhalation of miasms wafted in the air can lead us to apply preventive measures against.

13. That, with this view, in order to enable colonies to be planted upon insalubrious regions, I propose to *drain some suitable sites thoroughly;* to place a horizontal zinc or copper rod, or tube, in each drain; then to connect these cross-wires, or tubes, with two or more upright conducting or lightning rods, to carry away excess of electricity outside the habitation, and not to permit its passage up or down through the house or tenement, or through the bodies of its inmates.

14. That many trials have convinced me, that houses when built upon such insulated platforms, floored with non-conducting composts of asphalt or bitumen, and protected above and below from electric currents by copper tubes or wires, are comparatively healthy in all situations. These insulated chambers prevent the natural electricity of the bodies of men from being untowardly augmented, diminished, or irregularly distributed through them, by the *abstracted* or the *excited* electricity either of the earth or of the air, as I have many times witnessed.

15. That as many failures have occurred to common protecting lightning rods for want of moisture in the ground, in dry seasons and arid elevations, I have found hollow pipes, similar to our copper gas tubes, to present several advantages as lightning rods: by terminating below in the horizontal pipes or drains containing water, and by being always wet inside by the rain contained in them, their efficiency is secured.

16. This principle of insulating the areas or ground upon which the build-

ings are erected, is intended for habitations, hospitals, barracks, and all public or private edifices in malarious localities, and particularly in those places where the amount of insalubrity is prevalent and dangerous.

17. That for so-called malarious districts, wet floors, or low places, a thick layer of dry lime, fresh from the kilns, produces very favorable galvanic changes, abates the low indication of negative electricity of these places for the time, puts a speedy end to several chemical changes going on in sewers and soils, and tends very much to ameliorate the atmospheric condition of the insalubrious habitations, in so far as electro-galvanic currents and accumulations are concerned. Dry lime is a non-conductor, and has been useful in absorbing the moisture of damp rooms, and thereby diminishing their power of carrying electric currents to or from the inhabitants.

18. It had long since been proposed by Dr. Priestley to electrify a great number of patients at once, by placing them in a chamber raised upon glass feet. Mr. Ellis recommended, in 1831, that persons seized with cholera should receive their medical treatment in beds placed upon glass bottles, and be supplied with their remedies in glass vessels. All these ingenious suggestions were proposed for the use of persons already diseased; but my desire is to *prevent* persons from being epidemically diseased at all, as far as can possibly be accomplished. The above able gentlemen have suggested means of *cure;* I recommend measures of *prevention.* Their propositions were never carried into effect; whereas my insulated houses were *tried*, and saved the inmates from attacks of disease in places where laborers, when previously unprotected, fell by dozens in fainting and fevers, from want of sufficient electricity to sustain the natural balance. Persons insulated by a very bad conductor, such as a floor of cold asphalt, and by *clean dry flannel*, or other insulators, cannot readily communicate electricity to the earth, nor receive electricity from it, *if the air of the apartment be dry* where they sleep, and free from filth and moisture.

19. The following may serve to convey an outline of my reasons for insulating public and private buildings. A cloud, strongly charged with positive electricity over the individual, will attract his negative electricity upwards, and repel his positive electricity towards the earth. After the cloud is discharged, passes away, or is neutralized, the two elementary fluids rush towards each other into the centre of the person's body. This action of the opposite currents of the two elements often kills instantly. In milder cases, such electrical disturbance affects the animal fluids, as it affects beer in the cellar or milk in the dairy.

20. I consider that men's bodies, between the atmosphere and the earth, represent the chain of a Leyden jar, or of an electric machine, conducting negative electricity from the outside of the jar to the ground, or supplying positive electricity from the earth to the rubber. Were the surface of the floor well *insulated*, the chain could not readily give or receive the currents which otherwise pass through it.

21. Men, in like manner, may be saved in towns, camps, and houses, from being made the vehicles of currents which are quite capable of deranging the mechanical order, the chemical action, and the physical function, of every atom and organ of the human body.

22. That "*marsh miasm*" is a misnomer, and a weak invention to cover want of knowledge — a "*mysterious emanation*," supposed to arise like a spirit from the fenny deep, and to infect air, soil, and water — a pestilential something, reputed to be *malaria* itself. But no chemist has yet separated this germ of evil from the marshes in which it is thought to be engendered.

23. That early in life, a believer in these misty delusions of marsh poison, I did hope that improved tests and apparatus would arrest the "gas," and detect its composition. But continued trials, during twenty years, all failed to render it tangible. As yet, there has been no analysis of this "*pest*," although its sway is dreaded alike in the lowest valleys and on the highest hills.

24. That no doctrine can be more mischievous than this of "*miasms;*" for if there be such a poison, *sui generis*, wafted about in the air we breathe, there can be no precaution by which we may hope to ward off such an enemy while it continues unknown and unseen.

25. That no harm can result from any attempts to overturn the faith that was in us, and to believe in some other power capable in various ways of being felt, seen, heard, or understood. If, therefore, we come to ascertain that electricity at rest, or electricity in motion, or that some of its modifications, — galvanism or magnetism, — can induce a *broken balance* of electrical equivalents in animals, we may more easily devise means of warding off a known power, and preventing its transit through the conducting materials of living beings.

26. That while the relations of electrical influence to the laws of life are universally admitted, the very existence of marsh miasms may be well denied. An able writer observes that "their nature is not known; neither their physical nor their chemical properties have been ascertained. Even their presence is known only by their effects on the human constitution; no other test of their existence has yet been discovered. Some conjecture, that this poisonous gas is carbonic acid; others, that it is azote and oxygen; but chemistry has yet to discover whether this poison be simple or compound, as well as by what test, other than its action on the human body, its presence may be determined."

27. Were miasms of ponds and fens, of drains, sewers, and swamps, the exciting cause of cholera or agues, this pestilence, wafted in the fleeting winds, would be just as variable in its effects as the wind itself. We should then have every possible shade of suffering, but no parallel epidemics. Every variety of inhaled poisoning would prevail at the same time and place. But, on the contrary, intermittents and all symmetrical diseases, induced by symmetrical causes, are similar in character, and no two of them prevail in the same place and at the same time. Definite causes produce definite effects; and it was justly observed, in the late sanitary reports, "that cholera and

typhus seldom, if ever, rage in the same locality simultaneously, although the fever track and the cholera track are identical."

28. That by no hypothesis, deduced from the theory of miasms, can we account for the known fact, that in the Campagna di Roma, in Tuscany, Ceylon, and other places, localities are pointed out where malarious influence is insulated, and limited to defined spaces — as to one side of a hill, one range of a street, one end of a field, or even to one particular habitation. Malaria, tossed about in the air of Rome, will not account for one portion of the Via Babuina being infected, and not the other; nor will it explain why the dry and clean Pincian Hill, and the beautiful Monte Mario, are unhealthy, while the marshy streets and courts below are salutary; why the rich and well-planted grounds of the Villa Borghese are insalubrious, while the flooded Piazza Navonna, the Velabra, and the Jewish quarter are safe, like other crowded towns of equal temperature, on similar sanitary regulations.

29. That it is well known there are, even in these climates, numerous small spots of land, circumscribed by a distinct boundary, which have been noxious for ages. If this diseased state be owing to a want of equilibrium of galvanism in the earth or soil of such places, it merits a series of rigid trials, to examine their condition to the utmost extent, and to divert or cut off the sources of unequal galvanic influence, where unduly exerted. It is also known that, in various situations, physicians *cannot* readily cure or relieve certain nervous or rheumatic complaints, owing to causes which are undoubtedly electrical. This renders the removal from such localities absolutely necessary to sensitive patients, a change of air to whom, *is simply a change of habitual electricity.*

30. That the condition of low, decomposing, or fermenting places themselves might, in many instances, be improved by the means hereafter recommended; but to carry out in detail experiments and plans on a sufficient scale, should be the work of governments or municipalities, not of an individual. To arrive at conclusions of absolute certainty, experiments require to be instituted on an enlarged system. It is, however, fortunate that the chief means here pointed out will well repay their cost and trouble, by the diminution even of the former imputed causes of "*malaria.*" There is, therefore, the less necessity to dispute about the existence or non-existence of marsh miasms, if we can prevent or abate the desolation attributed to their influence in cities, towns, and marshy districts.

31. That whilst the nature, and even the very existence, of marsh miasm as a poison, *sui generis*, are without proof, demonstration, or reasonable explanation, the connection of electricity with all the agencies of nature is unbounded and undeniable. Its power is equal to the production of every effect here suggested. It is able to separate and again unite the elements of water, to tear metals from their oxides, to shake the clouds in thunder, and to operate in developing the evolutions of crystals. In its form of currents, it contorts the muscles of lifeless animals, and it flies, in its condensed form, instanta-

neously through a circuit of many persons, producing a manifest shock in them all.

32. That we observe, by experiment, how various is the quantity of electricity required to charge different persons. The amount is shown by obtaining sparks of the *same size*, from separate individuals, when equally insulated. Even their capacities for electricity, and their conducting powers, vary considerably. It is little wonder, then, that an endless diversity prevails in the ailments and sensations of persons who are so sensibly affected by what they call the state of the weather, damp, or the change of winds. These three enemies are supposed to be the actual perpetrators of injuries, which of themselves they have not the power to inflict. They are only *vehicles* of the disturber; they are not the real exciting cause; they only conduct it. They convey through the cold cottages of the poor, and the warm mansion of the rich, that invisible, subtile, disturbing agent, galvanism, which speedily probes and searches the bones, muscles, joints, and inmost organs of invalids, deranges the nervous functions, affects the animal spirits, and acts magnetically on the protoxide of iron in the veins.

33. Nature employs but few means to accomplish many ends. Electricity can produce thousands of effects; it is heat, light, galvanism, magnetism, and chemical action; or it is convertible into them. Its modifications constitute, in my opinion, that universal ether film which encircles all particles of matter, and preserves, by its powers of attraction and repulsion, the ultimate molecules of all organized bodies in their natural, relative connection and condition.

34. That, as a definite proportion of electricity belongs, and is peculiar to every thing, and as a natural quantity of it is essential to health, so any excess, deficiency, or derangement of it causes corresponding derangement in living bodies. As the integrity of specific atomic relation is essential to the identity and preservation of all beings, so the natural integrity of electrical equilibrium cannot be broken, or have its balance long disturbed, without an equal disturbance in all the functions influenced by definite electrical agency.

35. That observations and experiments give reason to believe, that there is a *certain* defined amount, plus or minus, (above or below the natural standard of electric agency,) that is capable of producing certain defined diseases, in susceptible individuals. In such localities as have their natural quantity of electricity reduced, augmented, or disturbed to the specific degree calculated to induce specific disorder, the effects of such derangement will be proportioned to the cause. The particular kind of epidemic will depend upon, and be equivalent to, certain assumed points in the scale of disturbed electricity.

36. I have noticed that this regulator of the balance is broken on many occasions, *long before* the consequent break of health sets in; that the loss of electric equilibrium in the earth and air *precedes* the loss of healthy equilibrium in man; that, like the supposed incubation of some disorders, the reaction consequent upon the oscillation of animal molecules does not

always advance, *pari passu*, with the occasion of their agitation; that in certain constitutions, the effects occur several months later than in others; that when the epidemic has set in, after the waves of positive or negative electricity had passed over or through a place, the epidemic has manifested itself *long after* the terrestrial or atmospheric condition of the district had been restored to a neutral state; either by the equalizing power of the thunder between *plus* and *minus* clouds, or by both these being blown away by currents of the air.

37. That it is only by careful atmospheric, and telluric examinations, we can learn the advent and cause of epidemics *before* their invasion; and that after they appear we may sometimes find the electricity of the situation restored in its due quantity or balance.

38. That from twenty years' practical experience, in a meteoric and marshy district, I have concluded that, as electricity in all probability is heat, or the active cause of heat, its laws hold similar relations to those of caloric. That, as cold is the absence of heat, the same electrical ratio applies to cold also; — that as water boils at 212°, strong nitric acid at 248°, oil of turpentine at 314°, sulphuric acid at 620°, and mercury at 662°, — so certain *steps* of electrical alterations, or disturbances, will reach certain peculiar epidemic consequences, or points. Each particular *step* produces its own particular results, in susceptible persons; and sooner or later, according to their aptitude or susceptibility.

39. That, as we are taught by experience, some people are scarcely liable at all to impulses of galvanic inequality; some are very slightly so and others slowly affected, or only after long intervals. We have also seen, that some persons escape altogether the shocks or oscillations of galvanic passes; others slightly feel their premonitory signs, or symptoms; whilst some withstand the concussions or derangements for weeks, or months. I cannot believe that similar differences would result, were marsh miasms, or poisons, (inhaled by breath,) the exciting cause; such active poisons, if in existence, and capable of destroying strong men in a few hours, would bring every human being within their reach under their destructive sway, without omission or delay.

40. That as free electricity very generally prevails in the air of most places, it may be asked, why *cholera* in man, and *blight* in vegetables, do not commonly prevail at all times. To this I reply, that the integuments, even of delicate human beings, are not susceptible of ordinary or slight electric passes, unless the part be moistened. The whole surface becomes moistened in hot climates by the dew at night; and hence I think that cholera or agues *invade* people at night, particularly towards morning; as we know that negative electricity reduces men in the rice lands of Italy to the most awful state of disorder. But were the cause, as said to be, miasms, extracted from fens by the heat of the sun, their lethal violence would, on the contrary, assail all persons by day. As multitudes labor in the fields by day, multitudes would fall by poison; but thousands escape the pest, *provided* they do not sleep in the air, or on any ground floor by night.

6

41. That I believe to produce certain grades of epidemics, certain stages of galvanic disturbance must be in operation. But it is seldom that such rates of derangement traverse the atmosphere or globe; consequently, we have not cholera or intermittents in all places, or at all times; although electricity, at rest or in motion, may be variable or disturbed, to a certain extent, in every situation. As we reach *definite* degrees of heat, to boil water, or to freeze it, we must contend with a *definite* degree of disturbance in galvanic force, fit to inflict epidemic catarrh, and a different definite point, sufficient to occasion epidemic cholera.

42. That I consider to cause specific diseases, similar in all respects, and parallel in progress, some specific agent must be in operation; such agent must be capable of producing peculiar symptoms, or signs of derangement, by exerting peculiar proportions, or quantities of disturbing actions.

43. That the latent galvanic equivalents in living things are seldom so much deranged as to damage the laws of life; mild degrees in the scale of disturbance inflict only mild corresponding ailments. Were we to assume, by way of illustration, a symbol of figurative quantity, as the neutral, latent, or natural equivalent of atomic electricity in a man, and state the standard amount [say] at ten thousand, or any other number of equivalents, then we might infer, that if ten degrees be added, abstracted, or *disturbed*, some local epidemic would result to persons similarly struck in that situation at the same time. As the cause (only ten degrees) is not considerable in this supposed case, so the effects will be mild in proportion. Periodical and nocturnal returns of old pains, nervous complaints, neuralgia, or nightly rheumatism, would probably be the symptoms of disorders corresponding to such points of definite or atomic galvanic alteration.

44. That when the east wind (almost always passively electrified) prevails; when stagnant rivers, ponds, sewers, cesspools, filthy streets, and drains, fens, or marshes, fed by changes of decomposing matters, create *galvanic troughs* of great extent and active energy; when their *intense* emanations flow in currents, and are linked to people by electric chains of vapor, damp air, wet floors, or filthy garments, — then, as the disturbing forces are severe, the loss of electric balance is severe also. Should the derangement of the balance amount to forty, fifty, or sixty degrees, out of the normal quantity, these points will correspond with the ratio of broken balance which may stand in relation to catarrh, epidemic influenza, diarrhœa, dysentery, fevers, and other local epidemics, similar in character under similar circumstances.

45. That, when millions on millions of horse power of galvanic forces are hourly evolved in the sultry morasses and festering deltas of the hot east; when strata after strata of our globe are daily galvanized, by communication or induction; when miles of excited earth transfer conduction to adjoining miles; when electric wave follows wave, flowing round in a zone of resistless disturbance; when a belt of such stupendous streams of untoward galvanism encircles the earth itself, which is the great source and reservoir of

electricity, — then it is no wonder that plants, fishes, birds, beasts, and men, placed over such an electrified girdle of the globe, should suffer, each according to their susceptibility and organization, and to the extent or continuance of oscillating currents. A hoop, or circumference, broader than the peninsula of India, conveying long-continued electric concussions and steam-electricity under land and water, will carry the disturbing range to eighty, ninety, or one hundred degrees, every series pointing to different series of disorders.

46. That there is reason to believe, a disturbed cincture arrives and retires with the revolutions of this planet. Perhaps the time may come, when the dreaded advent of these revolving sources of disturbance may be predicted by calculation, as the march of the cholera was estimated, in 1832, at the rate of about ninety miles per month. It is, therefore, when the excited air above, and the exhausted earth below, attract and repel long interchanges of galvanic emanations, that greater or more dangerous pathological degrees of disturbance ensue, fit to derange the scale to the point of such vast loss of balance as to indicate the exciting causes of typhus fever, sweating sickness, bubo plague, yellow fever, black vomit, and black death.

47. Within and around our cities and towns we contrive the most extensive batteries for extricating galvanism; we establish currents and counter currents of the electric [fluid], and of its *vehicles*; viz., the noisome gases, escaping up our pipes and drains. These foul airs rush up into our apartments, conducted by walls and floors, and carrying up currents of overpowering galvanic emanations. The walls and atmosphere of the rooms, being, in general, positively charged, induce negative passes from the human bodies within their range, and from the moist earth below attracting the electricity of the persons present, if of an opposite, and repelling it if of the same kind.

48. The vast number of chemical trials which I conducted in these marshy valleys, all demonstrated, as far as can be proved by *negative* evidence, that there is no such peculiar morbific agent (*per se*) as that which is understood by the name of marsh miasm, or paludial malaria. In most of these experiments, animal exhalations, *supposed putrine*, and organic remains, were traceable, with more or less of ammonia, in all the gases evolving in low fens or clay soils. But ammonia and all other impregnations were found in most regions of the air in Ireland, England, France, and Italy, where no epidemic at the time prevailed.

49. These results led to the conclusions which were afterwards confirmed by more extended researches in Italy. I found that when human beings recline upon moist ground, or on beds placed upon it, their *natural*, latent, or neutral electricity is disturbed or decomposed by the extensive surface of the body exposed to telluric attraction and repulsion of galvanic currents, conducted by the fatal chains of damp walls or floors, stagnant drains, filthy beds, or soiled clothing.

50. In the places described, extensive evaporation, and energetic chemical action during the day, charged the atmosphere of the place with positive gal-

vanic fluid. This surcharge passed through the moist conducting bodies of the people into the earth, attracting their negative and repelling their positive electricity. Again, when, during the diminution of the electric fluid of the air, before sunrise and sunset, the effervescing earth transmitted its excess upwards, through the persons so exposed, the neutral (fluid) in their bodies was disturbed, or the positive (fluid) was attracted to one side or extremity of the bodies, and the negative fluid repelled to the other side, and thus a process of attraction or repulsion exerted untoward oscillation in the bodies, brain, and spinal cord, and felt in particular, in the great sympathetic system.

In fine, we must conclude, that we are always under more or less *electric tension*, as the air is naturally positive, while the surface of the ground, together with all objects upon it, are in a preponderating negative state. It is, indeed, a matter of general observation, that this tension, or disturbed electrical condition of the atmosphere, whether it chances to be plus or minus, positive or negative, actually causes the more sensitive persons to feel otherwise unaccountably uncomfortable — sometimes as if all things were more than usually heavy, hard, noisy, or tiresome ; at other times, they are irresistibly irritable, excited, or restless ; at others, perhaps, depressed or melancholic. When the atmospheric electric deficiency is sudden and great, there is produced in nearly all persons, even in those in health, a certain mental depression, oppressive yawning, or uncomfortable feeling of gloom or discouragement. While a rapidly prevailing *surcharged* air, particularly if chafed by high, dry, and protracted winds, produces not only nervous irritation, unrest, and epidemic influenza, or prevalent colds, but even prevailing inflammatory diseases ; at the same time rendering a large portion of the sick, and persons with morbid nerves, worse ; while another large class of maladies and temperaments are as much benefited by it. So sure as autumn brings the blessing of harvest, and with that harvest also cholera infantum, epidemic dysentery, intermittent and bilious fevers, so sure will any considerable atmospheric electrical changes awaken all manner of painful affections. Repeated observation has made the author quite familiar with the coincidence of the prevalence of violent attacks of neuralgia, during, *or soon after*, the more brilliant displays of the electric and magnetic flashes of the aurora borealis.

CHAPTER II.

EARLY HISTORY OF MEDICAL ELECTRICITY.

History of the Medical Uses of Static Electricity.

OUR place is in the *new world*, our time in a *new age*. If we trace back but a little over one century, we shall find that medical electricity was a new theme, and formed but a short, undefined, and hence unimportant chapter in those works of systematic writers that treated of Therapeutics. The Leyden jar was then but just discovered; the physiological effects of the electric spark and shock were only surmised. Our Dr. Franklin had not demonstrated to the world the actual identity between the lightning of the clouds and the electricity produced by friction. But one hundred and fifty years ago and electricity developed from rubbing smooth pieces of wax and glass was the theme of universal wonder, and of scientific investigation. The astonishing powers, laws, and works of galvanism were utterly unsuspected. The relations of electricity to magnetism, and *vice versa*, remained yet hidden from the eyes of science for a long half century. Can we truly realize that water was then supposed by all the learned world to be a simple substance; that the laws of heat were unknown; that even the philosophers of 1760 did not dream of electricity as being the very *key* to physiology; to molecular physics, and hence to metaphysics; for penetrating and revealing the intimate structure, relation, and nature of bodies; that chemistry would be indebted to its subtile power for nice analysis and synthesis; for elucidating theories, and for forming entirely new compounds; that the physiologist would have deduced by its aid a most intimate knowledge of, and familiarity with, those innate forces that, hand in hand

with *vitality*, rule over living bodies, and are next to the very mainspring of life itself; and finally, that the physician and surgeon would find in it a very peculiar power for healing, and restoring from a class of diseases that baffled all skill, and were considered incurable? One hundred years before that, and it has been well said, that Newton was a schoolboy. Gravitation, or a code of laws for the universe, was unthought of. The globe had not been weighed as in a balance, nor had the true figure of the earth been recognized. Of course the "Principia" and the "Optics" of Sir Isaac Newton were as yet unwritten. Electricity and magnetism were scarcely acknowledged as sciences. Philosophers were speculating on their properties and their importance, but they never obtained a control over them. Can we realize, that but one hundred years before that, and we plunge into the very abyss of the *dark ages?* where, not only medicine and the physical sciences that relate to the healing art, but also all the physical sciences, were sleeping, as they had done for a long thousand years before? Without recounting our own otherwise untold inheritance of religious and social treasures, what rich *legacies* of chemistry, botany, geology, geography, mathematics, mechanics, physiology, electricity, and electro-magnetism were laying in stores for these generations then unborn! But over what was then known there lay a ponderous mass of dogmatic *theories*. No free discussion, no subject for dissection, no correct idea of the work of the lungs, or of the heart; no microscope, no barometer, or thermometer was heard of. In science there was as yet no minutiæ, or *speciality;* it was only at the risk of life that any new thought, or even any ascertained fact, was then given to the world. But now we come to an age that has both the facilities and the inducements for that minute and scrupulous observation, that discovers to us by the aid of inductive philosophy, as it were, new continents in science, inviting us to labor and usefulness. Such are the indissoluble links that bind electricity with physiology, and also with the whole science and art of medicine, that a more intimate study of it, in these relations at least, has become quite indispensable to all medical men of the present day. In therapeu-

ties the march of discovery is continually going on. Entirely new paths are opened; new methods of research, and of doing things, new instruments to facilitate the work, new laws are evolved, giving connection and combination of facts and phenomena which are unceasingly and increasingly accumulating around us. The discoveries of M. Matteucci, and of Dubois-Reymond have demonstrated to the equal astonishment and admiration of the present age, the curious, exquisite, and subtile relations which exist between voltaic electricity and the natural *functions* of nerves and muscles, not by any means proving the absolute identity of the nervous element of force with electricity, as some claim, but approximating a view that solves facts beyond all previous expectation. But who is able, after all, to discuss the actual relations of vital to physical forces, as applied especially to the human organism? Greater still would be the folly to plunge here into the depths of that still more abstruse question of the proximate relation of matter to mind, or into the domain of physical causes — to the total phenomena of animal life! None of this can occupy our time or space.

First, I wish to quote an account which has been given of the first shock of electricity, which electricity was accumulated, and then administered to the human body, by any explorer in this particular field of science. The simple story shows the utter astonishment that followed the effects. The historian says, "The end of the year 1745 and the beginning of the year 1746 were rendered famous by the discovery of the *accumulation* of electricity on glass, called the *Leyden vial*, so called because the experiment was made by a native of Leyden, Mr. Cuneres. But the person who made the discovery of the phenomenon was a Mr. Von Kleest, the dean of Cammin. On the 4th of November, 1745, the first electric shock was felt by this gentleman."

He says, when a nail, or a piece of thick brass wire, is put into an apothecary's glass vial, and this is electrified, then very remarkable effects do follow. Mr. Muschenbroek tried the experiment with a very thin glass bowl, and says in a letter to M. Reaumur, that he felt himself struck in his arms, shoulder, and breast, so that he lost his breath; and it was two days before he

recovered from the effects of the blow and terror; and that he would not take a second shock for the kingdom of France. Various accounts are given of the effects of such shocks, repeated by different persons in different places about those times; but we have space only for those of M. Winckle, of Leipsic. He says that "the first trial of the *Leyden experiment* produced great convulsions in his body; that it put his blood into such a state of great agitation that he was for a time afraid of an ardent fever, and was obliged to use refrigerent medicines; that he felt a heaviness in his head as if a great stone lay upon it. Twice it gave him a bleeding from the nose. His wife was the first woman who had the courage to try a shock, and from this she found herself so weak that she could hardly walk." Such were the first rude and rash experiments made with dynamic electricity on the human body by *shock;* but *sparks* were employed even before that; also for remedial purposes. M. Kratzenstein, a German physician, was the first to record, in 1744, a methodical treatment and cure, which was a case of paralysis of the fingers, cured by sparks drawn from the then common electrical machine. Next we find "A Treatise on the Effects of Electricity upon the living Human Body," by M. Jallabert, which was published in 1748. He sums up the most general phenomena observed from the application of electricity as follows: First, an acceleration of the pulse; second, an increase in the warmth of the part; and third, involuntary contractions actually produced in palsied muscles. This, we take it, must have been the first work on electro-therapeutics. Small as were the resources, and few the beneficial results, yet the then medical world did not let the matter rest, for the Abbé Sans, in 1772, published a work on medical electricity, in which are found reported the treatment of eight cases of paralysis, some cured and others very much benefited by the sparks and shocks, which was all that was known of electricity up to that time.

But in 1778, in consequence of a highly favorable account of the *curative effects of electricity*, which was made before the *Société Royale de Médecine*, at Paris, by Dr. Mauduit, the employment of electricity, for various diseases, through the med-

ical world, became more *fashionable*. He concluded that electricity was an exciting remedy; that it increases the vital powers; that it swells or plumps those diseased parts of the body which are touched by it; that it excites perspiration, and even salivation, (if not other secretions,) which become very profuse sometimes if the electricity be strong. He there gives, as his experience, that by a prudent use of electricity, patients were certainly relieved of obstinate pains; that the normal heat is restored in parts which had been cold even for years; that patients suffering from constipation sometimes experience abundant evacuations; that muscular wasting and paralysis, as well as œdema, are cured; that nerves are quieted, and a disposition to sleep is usually induced by electricity. In a few years after, M. Cavallo published all that was known on the subject up to his time, in his "Theory and Practice of Medical Electricity," which contains numerous valuable observations. He recommended to the profession the more frequent resort to *the electrical machine*, in their cases of paralysis, partial amaurosis, deafness, chorea, and epilepsy, and for resuscitating persons after being nearly drowned or suffocated.

The next considerable work on the remedial uses of static electricity appeared in 1802, although that was past the time of the galvanic and voltaic discoveries, and in connection with which latter the whole world of letters was flooded with piles and scraps of news or gossip relating to it, coming through every channel. This work was put forth by M. Sigaud de la Fond, on "Medical Electricity," which was as sweeping as our modern "*Electropathy;*" for, according to that work, there is scarcely a disease known in pathological anatomy that could not have been cured by those elaborately described methods which he laid down for its use. According to him, there were *seven* different methods of applying the electricity of the electrical machine, viz., by an electrical air bath, by drawing sparks, by giving sparks, by friction, by insufflation, by exhaustion, and by commotion.

There are some other less important works found, that were published in the latter part of the last century, upon this branch

of medicine; but they are not of value to be recorded here, excepting, perhaps, by allusion to one or two, to show the toleration of those most ridiculous notions which prevailed up to those times in all departments of regular medical practice. Signor Pinati, of Venice, introduced Peruvian balsams and a variety of other medicinal substances into the glass cylinders of the different electrical machines he employed for the different classes of diseases. One Dr. Giuseppi Bruni employed in the cylinder of the frictional machine, with which he operated, certain purgative medicines, and the patient, after having been thus electrified, (sic,) is said to have experienced the same effects as if he had swallowed the medicine!

However, the frictional machine has always found a place in the armamentarium of therapeutics to the present day, although very much less since Faraday discovered the *induction current* in 1831. Within and during the last fifteen years, static electricity has been considerably employed and made to accomplish some very wonderful cures in the electrical room of Guy's Hospital, in London, through the perseverance and skill of the celebrated Dr. Golding Bird; also, with and after him, by Dr. Gull, accurate accounts of which are found scattered along year by year in the voluminous reports of that noble and excellent institution.

As a matter of history, for the actual starting point in this branch of medicine, we must go back for more than two thousand years, even to the days of the great philosopher, Thales of Miletus, who ranked as one of the seven wise men of Greece — to him who founded the Ionic sect. It was he who first mentioned electricity as a remedial agent, some five hundred and forty-eight years before Christ. He also taught his pupils that electrized amber possessed a soul.

History of the Discovery and Medical Uses of Galvanism.

Galvanism, as is now well known, was discovered and demonstrated by Professor Luigi Galvani, of Bologna, in 1786, although he did not publish his discovery and commentary "*De Viribus*

Electricitatis in Motu Musculari" until 1791. In that work he laid down the proposition that there is a peculiar form or kind of electricity existing in all living animals, which he designated as *animal electricity*. As to his famous discovery, by means of the contractions of the legs of a dead frog, he believed that he merely *excited* and rendered sensible this native electricity by covering a nerve and a muscle with metallic conductors, but did not regard the latter as the real source of the electricity. In fact, Galvani based the explanation of the phenomena of muscle contractions on his *neuro-electric theory*. He assumed that all animals are endowed with an inherent electricity, exactly appropriate to their economy, which nerve-electricity, being secreted by the brain, resides mostly in the nerves, and by which it is communicated to every part of the body. The principal reservoirs of this electricity he considered to be in the fibres of the muscles, each of which he regarded as having two sides, i. e., opposite electric conditions. He believed, therefore, that when a muscle was *willed* to move, the nerves, aided by the brain, drew from the interior of the muscles some electricity; then, by discharging this upon their surface, which he believed to be negative, they were made to contract or draw together, and thus produce the required change of position. Thus, then, Galvani was the first not only to stumble upon the manifestation of a new form of electricity by the frog twitchings, but to blindly demonstrate *the existence of animal electricity;* for he verily thought it was that only which produced the phenomena. Here were given to the world two stupendous truths, by a single little prophetic fact! When he touched the sciatic nerve of a frog with one kind of metal, and at the same time touched the muscles of the leg with another kind of metal, while the other ends of the two bits of metal were in contact so as to form an arc, there was observed a sudden contraction of that leg of the recently killed frog; and this he interpreted as only evidence of an excitation of the peculiar electricity that was in the nerve and leg of the frog. He evidently did not comprehend that he had before him *two discoveries* in the one first experiment; that he was in fact demonstrating most clearly what we now know as galvanism, while

it was not so clear an evidence of animal electricity, but which was in fact equally as true.

It is said that Dr. Galvani, at that time Professor of Anatomy at Bologna, had his attention first drawn to an accidental and strange phenomenon by one of the medical students, that ultimately led him to the discovery of galvanism. Some frogs had just been dressed for a soup for Madame Galvani, who was an invalid, and hung along suspended by copper hooks connected to an iron railing. The student observed, that as these frogs' legs were moved by the wind, or other cause, so as to touch a lower part of the iron grating, they would at the same instant become "*convulsed*," and exhibit a peculiar twitching movement, which was repeated at every fresh contact, as if still alive. Dr. Galvani immediately commenced a series of experiments, to which he devoted himself almost exclusively for years, producing the same phenomenon in a more and more marked degree, by employing the legs of very recently killed frogs, and the application of certain metals both to the *nerve* and the *muscle* of the mutilated animals.

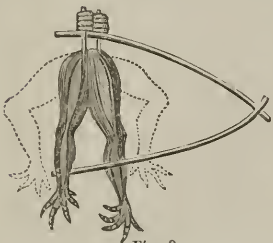


Fig. 3.

Shortly after the announcement of this discovery by Professor Galvani, this marvellous experiment was repeated by various scientific men in Europe, as well as in this country, as a curious circumstance. It appears that Galvani repeated and varied his experiments on the legs and nerves of the mutilated frog, again and again, for five successive years, before he put forth to the world *the fact*, and his explanation of it. But the very next year after the publication of this wonder of that day, Professor Volta, of Pavia, having set himself at once to the repeating this and other analogous experiments, publicly declared that he had arrived at a new and different conclusion as an explanation of the twitchings of the legs of the recently killed frog. He showed that the electricity was elicited *from the contact of two dissimilar metals*, while the contraction of the muscles of the frog was only an index of its existence. This explanation of Volta contained also substantial and important truth; but, from the heat

of the discussion, or from his peculiar disposition, notwithstanding his masterly learning and unquestioned ability, he could not see, or would not admit, the co-existing truth of his contemporary's theory of *animal electricity*. He utterly denied the existence of any sort of animal electricity, while he demonstrated that the arc of two different metals was the origin and cause of the electricity, and of the new wonder. And here were the germs of two stupendous discoveries; at first so apparently small as to be insignificant, and so imperfect and contradictory as to appear worthless, yet two fundamental laws in nature,—*animal electricity* and *galvanism*—with which mankind will ever after have much and still more and more to do.

A very sharp and protracted discussion arose between Galvani and Volta, and their respective partisans in all countries, in respect to *the first and sole cause* of the contractions produced by given means in the legs of the frog. Galvani persisted in assuming the existence of an animal electricity, which he believed to be *positive* on the surface of each muscle, while the negative electricity was condensed in the interior or body of the muscle, much as it can be in a Leyden jar, and that the nerves serve merely as conductors between the two coatings of this living species of Leyden jar. What a paradox! Yet, years afterwards, when Sir Charles Bell had discovered and pointed out the difference between the motory and sensory nerves, as being true in anatomy, this long doubted and even scouted idea of Galvani was seen and acknowledged to be not so far from the truth. But in those days, as we have said, Volta made it appear most conclusively that the electricity developed and manifested so curiously, was merely from the *contact* of two heterogeneous metals; and what confirmed this opinion was the simultaneous discovery of the power of the *pile* by Professor Volta; the construction of which was his own invention, but after all it was only the suggestion of Galvani's experiment, which was so doggedly opposed by M. Volta. Professor Galvani demonstrated, the next year after, that this contraction could be produced in the frog also by means of an arc or conductor of but one kind and piece of metal, or even without employing any kind of metal at all.

To make this fair and clear, Galvani would take a frog and first kill it; then quickly skin it; and then, by passing the point of a pair of sharp scissors *beneath* the two visible and easily accessible lumbar nerves, which always lie, as can be seen, by opening the abdomen of a frog and pressing the entrails to one side, as they naturally lie superficial for a half inch upon the psoas muscle and anterior to the vertebral column, so that the blades of the scissors embrace all the loins except the nerves; he then cuts again in the same manner a half inch above or below, so as to remove the two or three lower vertebræ, and leave the nerves intact and uninjured, but separate, reaching from the thighs to the body of the frog, suspended in the air like telegraph wires. He would then touch a nerve with one metal, and the muscle of the thigh by another metal, and then, when the outer end of these two metals touched, i. e., were in contact so as to form an arc from nerve to muscle, there was an instant powerful contraction. But as Volta objected, on account of the two metals employed, Galvani used a bit of wire of but one metal, one end of which touched the nerve, while the other was made to touch the muscle, and by this the same instantaneous contraction was produced, *but in less degree*. But Volta again objected, that however infinitesimal might be the conceivable difference in the homogeneity of the metal arc used for the conductor, it would be sufficient to produce an electric current that might be made perceivable by the delicate test of the contractions of the frog's leg; for this was indeed not only the most delicate test of electric currents, but it was the only galvanometer then known.

M. Galvani then attempted to produce the contractions without the employment of any sort of metal, or other foreign substance whatever. He therefore cut off the body from the projecting lumbar nerves, and then let the nerve fall upon the plate of glass upon which several such cut-off legs and nerves lay. He then would raise the nerve carefully with a small glass rod, and bring near and under it another frog's leg, and then let the raised nerve fall or touch gently but a single point on the external surface of the muscle; and this even produced contrac-

tions instantly and exactly as before, with the exception that they were more feeble even than in the second series of experiments, which was done by one metal. So conclusive was this final result, when the experiment was carefully done, that there was not a word left for reply by any convincible man; yet we find that Volta as persistently denied that final and grand result. By his great learning and masterly skill, he convinced or silenced the learned men of the world mostly, so that the prevailing public opinion settled down upon Volta's views, until he and his generation had mostly passed away.

Among those many who took a deep interest in this all-absorbing discussion of those times was Alexander von Humboldt; and before that century was closed, he had bestowed so much time and labor on these and other similar experiments, that he put forth unanswerable explanations that showed that those philosophers, Galvani and Volta, *were both right in the main*, but were in some respects wrong, and that here lay the cause of their difference. Baron Humboldt's conclusions were concurred in by Hufeland, Pfaff, and other distinguished German philosophers and physicians, who strongly urged the propriety and importance of searching for the best modes of employing electricity as a rational therapeutic agent, although they did not claim to have employed it themselves, except in their various experiments. These researches of Baron Humboldt were published in 1797, which in themselves show how ardently and thoroughly he went into this work, not failing to subject his own precious body to the corrosive action of metals which were applied immediately to purposely denuded and raw surfaces, as if to signify the greatness and sacredness of the subject he was determined to solve. He then explained and maintained the original views of Galvani, and gave him all praise for the patience and indomitable perseverance that so conclusively demonstrated the law of nature, viz., *animal electricity;* and at the same time offering such reasonable explanations, and yielding such praise for the discovery of the *voltaic pile*, that should have entirely reconciled those two Italian philosophers and their respective partisans. In 1799 Humboldt set out for his American travels, and

thus left the sway of creed to prevail with the Voltaic theory for the then thirty years to come.

Great novelty and furor attended the vast discoveries which were so constantly being made on the constitution of *inorganic matter*, by the aid of the truly magic pile of Volta, which was every day being modified, and in time greatly improved, so that a power was made available, that in the hands of Sir Humphry Davy, resolved many bodies, previously considered simple, into their constituent elements; and this quite changed both the nomenclature and the denominations of chemistry, creating as it were a new era in that department of science. Not only so, but still more recent, in the hands of England's Faraday, has it led to the actual discovery of new sciences, and of properties of matter before not dreamed of.

But in the mean time, the very curious phenomena observed in the frog could not be entirely forgotten, or neglected, by all the thoughtful and sagacious. Signor Valli, an Italian physician of great celebrity, commenced his researches as early as 1792, which was only one year after Galvani published his discovery, and *neuro-electric theory*. Dr. Valli believed the neuro-electric *fluid* to be secreted by the capillary arteries which supply the nerves, by which this fluid or *ether* became conveyed to the muscles,—which he believed to be always in an electric condition,—the interior being negative, while the exterior is positive. He also put forth the fact, that in experimenting on frogs, the nerves lose their irritability to the stimulus of electricity, *first at their origin or trunk*, but retaining it longer at their periphery or extremities. Upon this fact he hazarded the opinion, that probably "the distal extremities of nerves are the true origin of these structures." It is said of him that he was the first to form a battery or pile of some fourteen prepared frog thighs, and obtained thereby evidences of a true galvanic current. He publicly defended by demonstrations the almost obscured views of Galvani, by cutting the lumbar nerves of frogs high or near their exit from the vertebral canal, so as to leave them as long as could be, and then, raising them as delicately as possible with a glass rod, so as to touch a piece of any recent

muscle, such as cut from the flank of another frog, placed in a watch-glass in such a manner as to have no sort of connection with the frog, and thus he produced marked contractions. He also publicly repeated, from year to year, another of Galvani's experiments, which was to place on an insulating plane, or two separate planes of glass or wax, two separate thighs of a frog, prepared with long, projecting ischiatic nerves, which he bent into a semicircle on the cut end of the thighs, and then brought them together so that only the tips of the two nerves came in contact, when at that instant the two legs contracted energetically. But these results were doubtfully received by the learned world, notwithstanding the then young Baron von Humboldt advocated Galvani's and Valli's side of the question.

The most celebrated of the early treatises on medical galvanism was by Professor Aldini, of Bologna.* He states that he applied a very powerful current from a voltaic pile of some hundreds of pairs through his own head just above his ears, which so excited him that he continued sleepless for several days. He conceived that this treatment would be of service for that class of the insane who are melancholic, and relates the treatment of two cases that were actually cured by this means. He speaks of the great inconvenience of the voltaic pile, from its inconstant current, as well as expense and trouble. But before he published this work, he travelled over Europe, even through France and England, demonstrating and defending the theory of his illustrious uncle Galvani. It is evident that Professor Aldini's propositions and conclusions were of a high order and interest, since it is recorded of him, that when in London he appeared before the medical officers and pupils of Guy's Hospital in 1803, and there supported and defended a series of propositions so satisfactorily and conclusively, that he was presented by his auditors with a gold medal, commemorative of his labors. Besides, on leaving England, his propositions, together with the arguments in support of them, were prepared and published in a quarto volume, which, however, attracted so little attention,

* Essai theroique et experimental sur la Galvanisme. Bologne, 1804.

that in 1847, Dr. Golding Bird says, "I found the copy in the library of the Royal Medical and Chirurgical Society with the leaves uncut." I wish to make a record here of these early propositions of Aldini, because they so remarkably corroborate, as they evidently did also anticipate, the late brilliant researches of his countryman, Professor Matteucci. These propositions concisely were, —

1. "That muscular contractions are excited by the development of a fluid in the animal machine, which is conducted from the nerves to the muscles, without the concurrence, intervention, or action of metals."

In proof of this proposition, Aldini procured the head of a very recently killed ox, which was placed upon a table; also the posterior legs of a recently killed frog, which he held in one hand by the feet, so that the large *ischiatic* nerves hung down, and thus he caused the tip of the nerve of the frog to touch the tip of the tongue of the ox, which had been previously drawn a little out of the head and mouth. The circuit was completed by taking hold of one ear of the head of the ox by his other hand, also thoroughly wet. The instant the contact was made, there was contraction of the frog's legs, and the contraction ceasing the instant the circuit was broken. He also showed, that the intensity of these contractions was much increased by arranging several heads in a series, much as M. Matteucci did with the pectoral muscles of *pigeons*, some forty years afterwards.

He next so prepared a recently killed frog, that by holding up its leg by its toe in his fingers, and allowing its ischiatic nerve to be pendulous, he could bring its nerve in contact with its own tongue. Contractions instantly ensued from the current of electricity that thus evidently traversed the frog's leg, in its route from the external or periphery, to the internal or mucous covering of the body. If we interpret this experiment aright, it certainly demonstrates the existence of the musculo-cutaneous currents, and completely anticipates its discovery by Donne, some thirty-five years after. He substantiated those results by referring to the then physicians and professors of Guy's and

St. Thomas's Hospitals, who were present to witness the proceedings. His next statement was, —

2. "That the proper electric current of the frog is competent of itself to produce muscular contractions."

For the purpose of showing this, he prepared the posterior extremities of the recently killed frog that had been vigorous, and by bending up the leg, he brought the muscles of the thigh in contact with the lumbar nerves, when contractions instantly resulted.

Next Aldini took the prepared and separated frog thighs with their long ischiac nerves intact, and placed a ligature loosely around the middle of one of the nerves, which was then applied to a corresponding muscle; contractions ensued; but on tightening the ligature convulsions ceased. This statement, as remarked by Golding Bird, is highly important, for upon its accuracy or error hinges and depends what has been regarded as one of the tests of the *identity* or *diversity* of the electric and nervo-electric agencies. As soon as this phenomenon was announced, Dr. Valli repeated and entirely corroborated the result, with some modification; for he says, "I found that when the moist, tight ligature was applied lower down and near the muscle, it prevented the contraction; but if it is placed farther up, that is, near the spine, it will not prevent it." These same results were soon after corroborated by Von Humboldt, and still later by Professor Matteucci, who says, "If care is taken to insulate the nerve, a tight ligature does arrest the contractions." Before leaving the subject of Galvani's discovery, it is but justice to state that since Professor Matteucci, Golding Bird, and other writers have given currency to the statement that the curious phenomenon observed by Galvani was not original with him, (but that it had been made some time before by the celebrated Swammerdam, and that the experiment was exhibited by the latter in the presence of the Grand Duke of Tuscany,) this is *not found to be so*. The experiment referred to, says Dr. Althaus, of London, was for demonstrating nervous irritability from mere *nerve irritation by mechanical means*. Galvani's discovery was original. As to the contention between the two

illustrious philosophers, Galvani and Volta, there can be no shadow of doubt that the latter was wrong in denying absolutely the existence of animal electricity, because electricity was developed by contact of moist metals; so was Galvani wrong in seeing the muscle contractions only in the light of an effect of animal electricity, whatever might be the condition of the experiment. Volta was doubtless right, as to the explanation of the facts in the first experiments of Galvani. So was Galvani right as to the fact, and law, that muscle contractions are produced by the native animal electricity itself. For, by actual trial Galvani also showed that in warm-blooded animals there exist natural currents of animal electricity, directed from the extreme portions of the limbs towards the larger nerve trunks, and so on to the body. But this also was doubted for very many years, until, by the beautiful and strict researches of Dubois-Reymond, it has been completely confirmed. So was the third experiment of Galvani objected to by Volta, and rejected by the most of learned men also, because opposed by the latter on the grounds that the electric current then produced was from "*contact*" of dissimilar substances, as muscle and nerve; but, as we have shown, Galvani even succeeded at last in bringing about contractions by simply connecting the ends of the two large nerves of the frog thighs. This last result was flatly denied by Volta, but as strongly maintained by Baron Humboldt.

Years passed on. A very sensitive galvanometer multiplier having now been constructed by a German philosopher, the heat and bias of old prejudices having died out with the departed generation, and there being now no Volta, M. Nobili, of Riggio, took up the matter for thorough work, and from first principles, where Galvani and Humboldt had left them thirty years before. He was enabled to show again, and now conclusively, in consequence of new facilities, that there does actually exist in the leg of the frog, naturally, an electric current, or, in other words, *a nervo-electric current peculiar to the living animal.* The magnetic needle of the sensitive instrument he employed was deflected to 30°, by *the current proper of the frog*. This current he found moved in the direction from the muscles to

the nerves, and from the feet to the head. This action was often seen to continue for several hours, as the tissues of cold-blooded animals maintain the properties of life much longer than those of warm-blooded animals. Thus M. Nobili, in 1827, ascertained and demonstrated these facts, by means free from every objection, and denominated the phenomena "*the current proper of the frog*." Nobili found, if he touched the nerve and muscle of one frog, with the nerve and muscle of another frog, that there was no effect on the delicate galvanometer needle, showing that the one current was opposed to the other, and thus they balanced; but when he placed the nerve of one frog in contact with the muscle of another frog, then the needle deviated and a powerful contraction took place. But we must not follow now the fascinating progress of M. Nobili; for we are already arrived at the very portico of electro-physiology, that leads into a new and spacious wing of the temple of science. Here we shall find not only the cabinet of nature's laws by Nobili, but on the one hand we find Matteucci, and Marianini, and Volta, and Faraday; while on the other are Baron Humboldt, Dubois-Reymond, Todd, Copeland, Becquerel, Remak, Duchenne, Brown-Sequard, — together a mighty host. Let us then retrace our steps, and observe first what contemporaries have been doing since Humboldt left those countries for his memorable travels through our own America.

History of Electro-Physiologic and Electro-Therapeutic Researches.

I consider those observations, so early made by MM. Volta and Ritter, as being suggestive and important. Dr. Volta says, "These experiments can some day become applicable to physiology, as well as aid to the practice of medicine." But these expectations and prophetic declarations of that great physician are not as yet fulfilled, nor will they ever be realized fully until "the experiments" are directed *more to feel the way* to practice, rather than to discover the so-called *theory of convulsion.* Let but these same men turn their efforts to tracing the work-

ings of the different currents on the living organism in a therapeutical point of view, and substantial truths will soon accumulate; but we must first patiently investigate what has already been done.

M. Marianini, in 1829, and Nobili, in 1834, were the first to take up Volta's researches for thorough investigation. Marianini at once declares himself at some difference from Volta's views, because he supposed he found a difference in the opening convulsion; i. e., the twitching that occurs on opening the circuit; and this according to whether the current flows through the muscle, or whether it flows through the nerve trunk. The former he termed *idiopathic*, the latter *symptomatic* convulsions. In the first case, he thinks that each current direction, and in the latter merely that one running opposite to the nervous ramification, will admit of an opening convulsion. When the current courses through the nerves in a direction contrary to that of their ramifications, it will produce, instead of a contraction, a *sensation;* but when in the same direction as the nervous ramification, i. e., down-running, it will cause the contraction.

Such researches and results are all the more important and interesting, because they were for the first time obtained, not from the amputated frog legs, but from trials made on the live frog, with the loins necessarily separated transversely, so that the legs were connected with the body *only* by the large nerves. Thus, when a current was directed upward through the nerve, it produced at the opening of the chain a convulsion. If the direction of the current was changed so as to run down, it occasioned at the opening of the chain merely a cry from the frog; but this did not invariably appear. As in those times, the theory of C. Bell, or the microscopic structure of the nerves, were not as yet known, it is no wonder M. Marianini did not more fully see the prodigious bearing of these results of his own researches, but which our present knowledge proves them to deserve; namely, that the down-running current affects the sensitive nerves more than it does the motory nerves; and that also the opening of the down-running circuit is felt merely in

the sensitive nerves; while the opening of the up-running current is felt merely in the motory, where the electric stream traverses a mixed nerve. But we find that Dubois-Reymond, more recently, does not sanction the terms *idiopathic* and *symptomatic*, but says, "We do not yet possess any grounds on which to establish the immediate excitement of the muscles to motion, by means of the current, as we have no right to ascribe two causes for one and the same effect, when one is quite sufficient to account for it."

M. Nobili thereupon produced the results of his researches, which can be considered as forming an *epoch* — a second starting point — in the history of this department of physiology and therapeutics. The greater part of his work, however, was also directed to *the law of convulsions*, which was always thought by those earlier writers as so important. But in the latter part of his treatise we find the following conclusions, or rather doubtful deductions; for he says, —

"By the rapidly repeated closure and opening of the circuit that embraces a frog thigh, there appears a phenomenon which bears the greatest resemblance to ordinary tetanus." Nobili seems to suspect that in this idiopathic and traumatic disease, the nerve fibrils are subjected to similarly rapid changes of excitement and relaxation, that, taken together, produces the tetanic spasms. He states that he has observed more than once, that a frog which, from some unknown cause, had fallen into a tetanus, has remained in that condition also during the working of one direction of the current; but, by reversing the direction of that current, the muscles relaxed. He alludes to this fact for starting the query, whether the steady current working in one certain direction, or perhaps in both directions in *rapid* successions, may not possibly constitute the very specific means for quieting the tetanus, or rather the means for preventing its development; but he does not seem to take into the account any sort of reference to the cause of the tetanus; it must be assumed that the cause of the tetanus is already removed. Let us now, says Nobili, proceed from tetanus to paralysis, and ask, what is the real condition obtained when we apply an electric

current to a paralyzed member? The steady and long *uninterrupted* working of the current produces a stupefying effect on the nerves so treated, i. e., to a certain degree, so as to rob the nerve of a part of its excitability. But the working of a *rapidly interrupted* current, on the contrary, has a tendency to produce the opposite result; that is, to retain the excitability of the nerve in such activity as to produce even an artificial tetanus. In paralysis we conclude the nervous system has lost its excitability. In tetanus it has acquired a too great excitability. The treatment for the cure must therefore be diametrically opposite; for tetanus, the continuous voltaic current, by a steady and protracted working, stupefies the nerve; while for paralysis the interrupted current is needed to excite the susceptibility from moment to moment. Dr. Remak replies in answer to these propositions, that if the cause of ordinary tetanus really existed, like the artificial as produced by induction currents, for instance, i. e., in a similar change of the nerve fibrils, even then the expectation of a successful application of the steady current can receive our faith only as the current is at the same time able to remove the cause of the tetanus, which certainly would be a rather bold hope, in cases of traumatic tetanus. Almost as bold would it be, says Remak, to assert that the same means which produce tetanic convulsions (as the interrupted induction current of magneto-electricity) are also capable of subjecting paralyzed muscles to the power of the will, and even to impart to them that capability for action which is necessary for their normal function. Could it not be said, with as much reason, asks Remak, that such artificial tetanic convulsions will agitate or disturb the *molecules* of the muscle, so as to render it unfit ever again to obey the will?

Four years later, and M. Marianini declares that he finds that the *alternations* of Volta in the main are true; namely, that the longer working of the steady current direction makes the muscles insensible to the closing or opening of the circuit, if continued in the same direction; but that this sensibility is quite reëstablished as soon as the opposite current direction has worked about the same length of time, provided these currents

are moderate, as from a single pair. On the whole, he finds that the excitability decreases according to the frequency and the duration of the current directions. He then tested these seldom alternations with different strength of currents, as from two to sixty pairs of plates in the pile. By taking a vigorous frog and subjecting the posterior legs to the action of sixty pairs for three hours together, he found that the together-drawings and twitchings of the muscles had lost scarcely any of their strength. It was only after another half hour that they began to grow some weaker; but this was increased again on changing the current direction. After another three hours, there was no perceivable decrease in the muscle contractions from the first, although the current had now been running in all, and continuously, for six hours, and that with but one change in the current. In short, it was found that only by a very long duration of the current, there was noticed any further reduction in the contractions, and that by the change of the current direction these were restored again.

According to these results, says Marianini, there exists in *living*, healthy animals, *a repairing force*, which was here manifested by restoring the contractions produced by the protracted electric current. In fact, as soon as a live frog has become weakened from the teasings of electric experiments, if it is allowed a time to rest, it reacquires its original strength, and the contractions show the same force, (without the necessity of changing the current direction,) as was observed at first. According to him, this *repairing force* continues in some degree in the recently amputated frog leg, but then only for a short time, for the longer the time that has elapsed since the section, the shorter in-working of the current is required to make visible the reduction of its excitability, which simply means, *lost strength*, as first discovered by Volta.

M. Marianini then goes on to speak of the *alternations* of Volta, which, from the application of very frequently interrupted currents, he observed produced convulsions, i. e., muscular contractions. When, by the frequent interruptions of the current, the convulsions, at first so strongly produced, begin to decrease,

they again increase in strength as soon as the direction of the electric current is changed. He also repeats the observation of M. Ritter, that the opening convulsions increase in strength after frequent interruptions of the current, while the closing convulsions decrease; and that the appearance of *opening* convulsions during a treatment is always a sure sign that the aim of the alternation, i. e., to render the preparation for the thorough in-working of the succeeding and opposite stream direction, has been reached. M. Marianini endeavored by extended and prodigious research to find explanations for all the various phenomena of Volta's *alternations*. "On this Dr. Remak observes, in the first place we often find stated by accurate observers, that people treated by repeated but moderate shocks, from interruptions of the current, thereby become so much the more susceptible to them, the oftener they receive them. Every one thus treating patients must observe, that there is a growing susceptibility to even weaker and weaker currents after the few first days, which, however, we must not always take as predicting an amelioration of the sick person's condition. Similar to these mild shocks from broken currents, does the *continuous current* work, for when it acts on sensitive parts the sensibility gradually increases—a fact already observed by Volta and Von Humboldt."

M. Marianini, in order to sustain his views,—according to which, the opening of a strong and long working current leaves in the traversed muscle or nerve a surcharge of electricity, which endeavors to quit the organ in an opposite direction,—he calls attention to the tetanic conditions which are sometimes perceivable in the frog thighs *after* the opening of a strong current, as well as during the steady uninterrupted working of that current.

Dr. Heidenhain has made some practical observations as to the restoring from an absolutely sunken excitability of nerves and muscles. He says a frog had lost, during teasings from experiments by many hours' alternations with sixty pairs, all excitability or capability for together-drawings of the muscles. It was then left for five hours under the action of the continuous

current of the same pile, when, on the opening of the circuit, and much more on the reversion of the current, it showed manifest contractions. He at another time left the two thighs of a decapitated frog for five hours exposed to the continuous current of seven voltaic pairs, so that one foot was in connection with the positive pole, while the other was in contact with the negative pole. There appeared at the end of that time no sort of contractions, either at the closure or opening of the current. But when the same was now again exposed, for five hours and fifty minutes, to the action of a *reversed* current direction of sixty pairs, it actually regained its excitability in such a degree as to respond not only to the same current strength, but even responding to seven pairs, and a little to three pairs of plates.

Thus, according to M. Marianini, the stupefying or weakening effects from the long and continuous action of a moderate current, first declared by Volta, do not appear in fact at all; or at most, not until after many hours, and then always very indistinctly.

It is to be noticed here, that M. Matteucci did not follow out these researches of M. Marianini, on the steady working of the current, but directed his attention mainly to the department of animal electricity, thus extending Nobili's discoveries. In connection with Dr. Farina in 1838, he made trial in Turin with the continuous and steady working current of galvanism, using thirty to forty pairs, in a case of traumatic tetanus, which occurred in a man mortally wounded. An up-running current was first employed through the spine from the sacrum to the nuche, and to avoid entrance convulsions, they managed, after applying one pole and retaining it *in situ*, to get the other on very gradually by means of a wet strip of cloth connected with the second electrode. This gave as positive and favorable results as the nature of the case could admit of.

M. Matteucci then says, that he has found that when frogs have been tetanized by strychnine, or by opium, the tonic convulsions can be dissolved down, so that death sets in after due time without any further convulsions *by using even and continuous currents*. In his treatise "on the electro-physiological phenomena in animals," he urges the importance of the electric

current for remedial purposes. The up-running current he thinks best suited to allay tetanus and convulsions, if the entrance convulsion is only avoided. He mostly agrees with Nobili on the action of Volta's alternatives, as for instance where a nerve has been deprived of its excitability by a given prolonged current direction, it is re-acquired simply by the reversion of the direction of the current; and furthermore, as Marianini discovered, so Matteucci verifies, that the up-running current excites mostly the *motory* nerves, the down-running current excites mostly the *sentient* nerves; but presupposing always that the disease or derangement of the nerves is akin to that condition which can be produced by a strong, even, and long continued current in the same direction.

We now approach another epoch in the history of electro-physiology and electro-therapeutics: I refer to the researches of M. Dubois-Reymond. It appears to have been the main object of this great man to test and put to rest the truth as to the nature of the powers active in the nerves and muscles of living men. To demonstrate, — the identity, or *degree of identity*, there is between the electro-motive force, artificially produced, and the functional force of the living human organism, and to ascertain the workings of electric currents through the nerves and muscles as nature's method or means to put the original powers of these textures into action, — we shall have to recur frequently to the general theory of *nerve and muscle excitement* developed in his hands, from the very careful and conscientious trials he so perseveringly instituted.

The *electro-tonic state*, or "electrotonus," so nicely examined by him, arrests our first attention. After Dubois-Reymond had ascertained that not merely the muscles, but also the nerves, of a recently amputated limb show a *sui generis* electrical current, called the *quiet nerve current*, and always flowing from the longitudinal to the transverse cut of muscles, he observed, —

1. That this native current *increases in strength* as long as a constant current is made to flow along on the edge or side part of the nerve region that is being tested, provided the artificial current, that is so applied, runs in the same direction with the natural nerve and muscle current.

2. That the native nerve and muscle current *decreases* when the artificial constant current is made to run in the *reversed* direction.

3. That the native nerve and muscle current *ceases* to flow, while and as long as the nerve is disturbed, or is being excited, as by means of interrupted induction currents; or by mechanical or chemical irritations that are strong enough to produce a motion or sensation. The last-mentioned oscillating or staggering of the nerve current is by Dubois-Reymond termed the *negative state*, while the first-mentioned changes he terms the *electro-tonic state* of the nerves.

The physiologic, and I may add the therapeutic signification of this electrotonus amounts to about this: That we see, after the application of the constant galvanic current, certain changes are produced in the nerve, parallel with, but to the one side, from the direct route of the applied artificial current. In this sense we see that the labors of Eckhard and others concur, by tracing the share of the physiological workings, that attend the galvanic excitement, as is done partly inside and partly outside the tested region. These observations of his may be found in the second volume of his works. Dr. Remak observes, that these facts are so important to his mind "that they are the very starting point and stopping point for operations in all electro-therapeutics." The propagation of this electro-tonic state is doubtless arrested by the under-tying and then cutting through the nerve, and from this is proved that the *pile-formed* polarization of the nerve stands related to the "first cause" by which sensation and motion are produced.

This view, deduced from all these facts, is also verified by another fact — *that the electro-tonic condition of the nerves is developed under all those circumstances by which the action of the nerves appear visibly increased;* and that this ends in contractions, that is, with the *mechanically expressed capability of the nerves and muscles for action.* This, however, by no means should lead us to mistake this electrotonus as one and the same thing, exactly as that natural circumstance or cause that produces sensation and contraction. This circumstance, or

cause, is temporarily called forth by the artificial application of the current, at the moment of interruption, or by alternation, or by an increase or decrease in the *density* of the current,—which also causes the positive or negative variation in the native electric current in the nerve; but electrotonus continues of the same strength as long as the circuit remains closed, even when the artificial current is weak.

Dubois-Reymond, in order to point out the true signification of the electrotonus, reminds us of the proposition which Ritter and Erman had already advanced on the theory of convulsions, and thus discovered a *law*, partly from the after observations of Nobili, and partly from those of MM. Becquerel and Matteucci, namely, that the circumstance, or cause, producing motion, and arising at the moment the circuit is closed, is to be found in the electro-molecular change of the nerve, which is in effect *an altered condition of the nerve;* that, moreover, the activity of the applied current consists in placing the nerve in this condition and *maintaining* it so as long as the electric current is directed there; that finally, the opening convulsion is nothing else than the *replacing* of the nerve from the changed condition, back again into its natural state, as soon as the restraint of the irritating current has been removed. From this, too, arose the aphorism of Ritter, "*It is the organism, and no other, which produces on itself the opening shock.*"

We are here also reminded of those ideas of Dr. Erman, that the essence of the inworking of the current consisted in producing a more rapid chemical action in the tissues, i. e., a superior oxidation and hydrogenization in the one and the other half of the nerve; and also are we reminded how Nobili made a difference in the change brought about, by the up-running and by the down-running current, by terming it either "direct alternation," or "inverse alternation," in order to correspond with his explanation of the theory of convulsions.

Dubois-Reymond goes on to say. If I am not entirely deceived, we are now enabled to fill up the theory of Nobili in a truly philosophic manner. It is my opinion, he says,—to the formation of which I think myself justified by facts,—that we

have been convinced of that lasting alteration in the nerves, obtained in the electro-tonic state, from the action of the electric current — an alteration which it was only given to Ritter, Erman, and Nobili to *suspect*.

When a current acts upon a nerve, the latter then becomes circumstanced the same as any other wet conductor. Electrolysis is produced, commencing with pile-formed or pyramidal polarization. The change from a natural into a di-polar adjustment of the electro-motory molecules occasions that disturbance of equilibrium, which shows itself according to the direction of the current in a closing convulsion, or in a closing pain. It is the return from the bi-polar to the natural adjustment again, by which, to speak in Ritter's words, the organism gives to itself the opening shock. In short, this galvanic phenomenon appears to be a particular example of that discovered by Nicolson and Carlyle, then appearing so strange only on account of this particular property of the animal conductor.

To these observations Dubois-Reymond advances a justification for the term *electrotonus*, as applied by him to nerves and muscles. He, in the first place, reminds us of the already stated similarity that appears between the source or cause of the nerve excitement by means of the current, and that of the induction of a current-leading conductor, or magnet, to a neighboring and parallel conductor. Just as that element which produces sensation and motion does not always arise to the same degree during the continuance of the current, so the induction takes place only in consequence of positive and negative alterations in the electro-dynamic or magnetic resultants, acting on the conducting element. Now, as Faraday has designated that condition of the conductor, into which it has been brought by induction causes, *as the electro-tonic condition*, — the actual existence of which he in latter researches has been able to demonstrate by ocular means, — so the pile-form polarization of the nerve is entitled to the designation which Faraday has thus prepared for it.

When a current is produced by closing a circuit that embraces a living nerve, it is accompanied by an excitement and

disturbance of the element of motion and sensation. The nerve, indeed, becomes polarized, pile-formed, or in pyramidal order, which is the electro-tonic condition. When both poles of the battery are removed, and the current is thus opened, the electro-tonic condition of the nerve-conductor disappears, and the molecules return from the induced di-polar to the natural polar state of a healthy nerve; whereby we see manifested the same contrast between the closing and the opening convulsion as between the closing and opening current, viz., the closing convulsion shows by the down-running currents the same peculiarities which the opening convulsion presents by the up-running current, and *vice versa.*

Dr. Robert Remak, of Berlin, says, that although Dubois-Reymond has produced and shown the electro-tonic state of the nerves, even when he used interrupted currents for exciting them, nevertheless, we are by no means allowed to suppose that the action of the *interruption* did, in itself, contain the *cause* of the induced condition of the nerves. On the contrary, he says, Dubois-Reymond shows, by a long series of the most careful experiments, that the result of the tetanizing of the nerves by alternating currents, and even of the tetanus produced in those which cannot be electrized in consequence of strychnine, or other chemical hinderance, *is a negative fluctuation* of the *native* nerve-current. Therefore it is made probable, by comparing all the conditions under which, on the one hand, convulsions appear, and on the other, where negative stream fluctuations are shown to be in the nerves; that this negative fluctuation is the true electro-motory expression of the element, or cause, of motion and sensation, which appears in the nerve whenever its inner equilibrium is disturbed by mechanical, caustic, or chemical causes, or every time it is placed by an exciting current into the electro-tonic condition.

Finally, that this condition undergoes a certain fluctuation in consequence of a similar fluctuation of the exciting electric current, the density of which stands within certain limits, and that in a simple ratio to the strength of the electro-tonic condition. In view of such intensely interesting facts, Dr. Remak most justly says, "How the field of the physiological pre-trials and

studies relating to electro-therapeutics is of late enlarged by all these researches and discoveries!"

Is electrotonus the inseparable expression of the excitement produced by the steady current working during the closure of the circuit, and are the negative fluctuations of the native current of the nerves and muscles, on the contrary, the consequence and the expression of the fluctuation or interruption of the exciting current? Then every research, even the most minute and delicate; that relates to the formation of these conditions, will be of influence on the vital question of relation or condition of the nerves in the human organism, according as they are exposed to steady currents, or to greater or less current fluctuations.

Next in order comes "The Galvanic Current, a *Preventer* of Muscle Convulsions," a treatise by Dr. Eckhard; the maxim of which is, "Every muscle convulsion responding too readily to the influence of some irritation, can be avoided by means of the constant galvanic current; and every tetanus already present can be removed by it." He proves this rule by three series of experiments, *not on living animals*, but on amputated, and hence dead frog legs. These are the evidences: —

1. A nerve embraced in a circuit of four or five Daniell's elements can be affected in the route of the current, without producing convulsions; but these convulsions will at once reappear as soon as the current is opened.

2. If a nerve is saturated with a solution of kitchen salt, by which it is well known that a frog's leg is tetanized, and is then taken in the galvanic circuit, beyond or below the portion of the nerve irritated with the salt, then there does not arise any tetanus, or, if it does appear, it quickly vanishes as the circuit is closed. When the current is weak, an up-running current is most successful; but when stronger currents are employed, either direction is effectual.

3. If we now employ two batteries separately, but upon the same limb, so that the upper end of the nerve is embraced by the weaker battery circuit, at the same time that the lower extremity of the limb is in the stronger current, then the closure and opening of the upper circuit, during the constant closure of the

lower one, are incapable of exciting convulsions, which, however, at once appear as soon as the electrodes of the lower circuit advance a little on the muscle. Then, if the direction of the current is reversed, we will find it requires a greater difference in the strength of the two circuits to render the opening and closure of the lower one ineffective; therefore, where weak currents are employed, the up-running current from both batteries will prove the most favorable. Dr. Eckhard is evidently mostly interested and mainly occupied in discovering the differences obtained from the different stream directions, and says he finds the up-running current to prove the most paralyzing. But he himself as evidently contradicts this statement in all his subsequent deductions. From such unfortunate statements has arisen a very great prejudice in the minds of medical practitioners against employing the primary steady current of galvanism *with occasional* interruptions or changes in density.

Another proposition of Dr. Eckhard's is, "Every constant current that flows through the motory nerves occasions on the traversed part, and that lying above the positive electrode, a diminution of excitability, while, on the other hand, the excitability increases in the part situated under and beyond the negative electrode. Moreover, that the excitability is *always* increased underneath the negative electrode of the circuit *when* it is so situated as to work at the upper end of the nerve in a downward direction."

Dr. Heidenhain subjected these opinions to a series of rigid trials, and concludes, without however being aware of Marianini's results, that a muscle, or group of muscles, which, either from straining, extreme heat, or teasing by abusive induction shocks, (or by any other means,) has been deprived of its excitability, regains its power of contracting by the aid of the steady continuous galvanic current, and that more rapidly by means of the up-running current than when its course is downwards.

Dr. Pflüger, on the other side, subjected others of M. Echard's experiments to trials, and he concludes that the stream fluctuations of a constant current do not produce equal *shortening* of the muscles, or portions of the muscles, through the

whole extent of ramification of that nerve through the muscles; but that *the contractions grow stronger in proportion as the irritation is applied near the central end.*

If, now, says Dr. Remak, we keep an eye on this result, and then test the relation a nerve bears (while the central end is coursed through by a steady down-running current from a moderate battery,) to electric current fluctuations, we shall find, as Dr. Eckhard has already observed, the ability of the nerve to respond by the visible contractions of the depending muscles to the fluctuations of the current, and that to increase below and about the negative electrode, while this increase is found diminished again farther on towards the periphery. And second, we find that a constant steady current, which runs *down* the nerve in the neighborhood of the muscle, to operate quite differently; for it exerts its influence also upward, and occasions a decrease of the contraction or twitching produced in the neighborhood of the positive electrode by the fluctuations of a down-running current; but said *decrease* becomes less towards the top, and ceases altogether before the end is reached. Third, if the central end of a nerve is coursed through by an *upward* current, we shall find, it is true, that the susceptibility of the nerve and muscle to fluctuations of the current decreases below the positive electrode; but it is also true, that this diminishes, and even ceases, before reaching the extreme part of the muscle. Fourth, and finally, if the steady up-running current operates in the neighborhood of a muscle, while at the same time a fluctuating current of another battery is all the while working above it, and in a different current direction, we shall find, to be sure, that the twitchings, or muscle contractions, increase in the vicinity of the negative electrode; but it is also true, that this increase decreases again, in proportion as we approach the central end.

Dr. J. Rosenthall has recently published a work on "The Modification of the Excitability of the Nerves by Means of constant Galvanic Currents and the Alternations of Ritter." The argument of this work may be comprehended in the following: Every constant current which courses through a nerve for a certain time, places the nerve in a condition in which the sus-

ceptibility to the *opening* of a given in-working current, and to the *closure* of an opposite current, is *increased*, while, on the contrary, it has *decreased* to the closure of the former, and to the opening of the latter; that after a steady in-working of a strong current — say from two minutes to an hour — on a nerve trunk, then the muscles ramified by that nerve fall into the so-called "Tetanus of Ritter," but which is calmed by the closure again of the same current, or even by using a weaker current. But it will be strengthened by the reversed direction, even if we use a weaker current. At lower degrees of excitability, twitchings appear, and not tetanus, at the opening of the current, and at the closure of the opposite direction — the muscles remaining, on the contrary, quite at rest, both at the closure of the first and opening of the latter. In all these respects, then, we learn that the workings of the down-running current appear less constant, less permanent.

In the year 1825, Dr. Sarlandiere proposed applying galvanic currents by the means of *acu-puncture needles*, so as to bring the action of electricity more directly to the nerve or seat of pain. M. Magendie soon took up the matter with no little interest. He succeeded thus in effecting some wonderful cures, even where all other medication had failed, as in cases of amaurosis, neuralgia, and paralysis.

Next, MM. Guerord and Pravaz proposed treating aneurisms for radical cure by these same means. This high operation on a living man was first attempted by Professor Liston; but the first successful operation of the kind was performed by M. Petrequin, in a case of popliteal aneurism.

For performing the *electro-cautery*, Middeldorpff, Stunheil, and Amussatt employed fine platinum wires, bent to a sharp angle, and rendered incandescent by *quantity-galvanism*. Provost, Alexander Dumas, Bonnet, Bence Jones, and others have operated, and in some instances succeeded in decomposing calculi in the living human bladder, (but this is not advised as safe and practical.) Dr. Golding Bird and Mr. Spencer Wells have applied single pairs of silver and zinc plates for a voltaic action on the skin where placed, and for promoting the growth of healthy granulations in indolent ulcers, &c.

But for the remedial use of the primary currents of galvanism, *not* as a cautery, but as a peculiar nervine, by a catalytical or polarizing effect on the nerves and muscles, we find Dr. Robert Remak, a Prussian physician, the most strenuous recent advocate.

CHAPTER III.

ELECTRICAL INSTRUMENTS FOR MEDICAL PURPOSES.

FOR therapeutical means we may have recourse to three *classes* of electrical instruments, viz., the Electric Machine, the Galvanic Battery, or the Induction Apparatus. There is quite a variety of instruments in all three classes, but we should choose them according to their *action*, and the *form* of the element they respectively produce. Electricity in motion, as we have seen, results from the reunion or neutralization of the two separated opposite electric principles. This may be *instantaneous*, *intermitted*, or *continuous*. In the former case it constitutes the simple *discharge;* in the second case a more or less *continuous* current; in the third, there are produced rapidly *interrupted* currents, which are usually as frequently alternated or reversed. Therefore the latter, as electro-magnetism, is best wherever we wish rapidly discontinuous and alternated currents. The galvanic battery is best for sustaining a more or less *continuous* current in a given direction. The friction "electrical machine" is the best for producing electricity of high tension, as sparks, or the instantaneous discharge, also called the "shock."

By the *electrical machine* we get a peculiar form of electricity for remedial purposes, possessing *great intensity*, while there is but *feeble quantity*. This machine may consist of a revolving cylinder, or plate of glass, which is submitted to the friction of cushions or rubbers. As a general thing, a plate machine is, for equal size, of far higher power than the cylinder; but it matters very little which form of friction machine is used. If we were going to purchase for practical purposes, we should de-

cidedly prefer the plate machine, and the plate should not measure less than twenty inches. The room for operating should be a dry one. When the air is moist it must be dried and warmed by furnace heat, or other means, and the glass plate, as well as the insulating supporters of the prime conductor, of the axle of the glass and of the rubber, should be rubbed with a hot, dry cloth, not only to free the machine of moisture, but also from dust, which is as hurtful as moisture to the preservation of electricity on insulated conductors. Hence, the apparatus, together with all the appliances about it, must be kept scrupulously neat and dry.

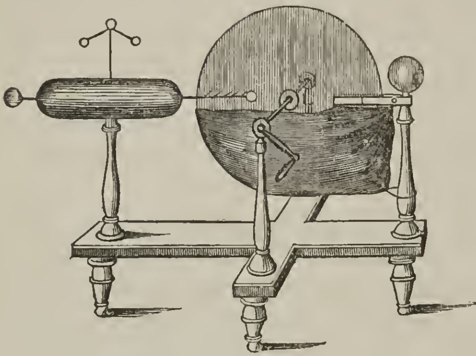


Fig. 4.

I have found that in humid weather, or when the atmosphere is negative as from an approaching storm, that if the glass plate is moistened with a very trifle of sweet oil, it is of advantage; also, that the surface of the rubbers must be from time to time renewed with an amalgam powder of zinc, or deuto-sulphuret of tin, which can be had of any philosophical instrument maker. Another arrangement or provision is also necessary; and that is, a good contact conductor with the actual moist earth, or a large body of metal. This should be some way adjustable near the machine, so as to be readily put in contact with the rubber, or negative pole, while we are charging the prime conductor *positively*, as also for drawing sparks from the patient, or for charging the Leyden jars; also, so that at another time it can be removed to the prime conductor while we are employing *negative* electricity from the rubber end of the machine, for the rubber is always the negative, and the prime conductor is positive. And here comes in the *law, that the one is never evolved without the other;* therefore, if we wish to use or accumulate the one, the

other must be as freely dissipated without hinderance, and if this point is well attended to, the power and uniformity of the machine will be greatly enhanced. The dry wall or chimney of the house is not always sufficient. A large copper wire leading to the moist earth, or connected with a water pipe, or gas pipe, by good metallic contact, is the most reliable. But, of course, where we wish to employ both electricities at once, we must not make either the rubber or the prime conductor communicate with the ground, but rather keep all well insulated. In every case the electricity is set free on the *surface* of the rubbed glass plate, or cylinder, the negative flying to the rubber, while the positive accumulates upon the glass, which induces it also by sharp points in the prime conductor; and from here we can accumulate even greater quantities still by means of Leyden jars. The power of the jar is in proportion to the size; i. e., a half gallon jar is twice as powerful as a quart jar, if each is fully charged; for the former will receive twice as many turns of the machine to charge it. If the outside tin foil coverings of two or more of these jars are put in communication, as, for instance, if set upon a sheet of tin foil, and at the same time the metal stems that communicate with the inner lining foil are joined also as by a chain, they thus become by this double connection as one jar, and can be charged and discharged through any one alone. This is called a *battery of friction electricity*.


Fig. 5.

Thus the inner coat of the jar receives positive electricity from the prime conductor, while negative electricity is then always accumulated on the outside of the jar, or conductor that leads it off. Now, if a communication is made between the inner and the outer coatings of the jar directly, as by means of a discharge, or indirectly, as through the human body, a neutralization of the two electricities takes place with a loud crack and flash. If the negative charge is required, the prime conductor must communicate with the *outer* covering of the jar, &c.; but usually it is the positive charge that we have to do with. If the jar is discharged through the human body, there is a violent,

sudden, and unpleasant sensation, which we term the *electric shock.* The strength of this shock is mainly in direct ratio to the extent of the metallic coating of the jar, and to the degree of high intensity with which that is charged and the susceptibility of the patient who receives it. This may be transmitted through one person, or even through a great number of persons in a chain, if the first person takes hold of the recently charged jar near its bottom, while the last person in the circle then touches with his finger the knob or ball on the top of the jar, and while they all hold each other by the hand. If several jars are properly united and fully charged, they might give a shock through the human body, by its action on the nervous system and the natural animal-currents that would exhaust them to such a degree, that it might prove as fatal as lightning itself.

The *discharger* is a necessary accompaniment of this machine, which consists either of stationary or adjustable metal arms, tipped with brass balls, and provided with a long glass handle. I find that *two* of these dischargers are more convenient than one, as for making discharges through the pelvis from the sacrum or lumbar region to the top of the pubis, in cases of dismenorrhœa. But it is necessary to approach the charged Leyden jar with the brass balls of the discharger *always in one order;* and that is, *first* make a ball to come in contact with the *outside of the charged jar*, *before* the contact is made with the knob on the top of the jar; for if the machine works well, and the reverse order is carelessly taken, i. e., to touch the top knob first, and then the outside of the jar the last, it will be very likely to break or to be perforated, and thus spoil the jar for further use. Another condition already alluded to, is necessary to succeed the best possible in charging a Leyden jar — for in medical practice but one or two at most are ever wanted. The outer foil of the jar must be in communication with the conductor to the earth, so as to utterly dissipate the negative electricity from outside the jar while it is being charged inside positively. But I must here take space

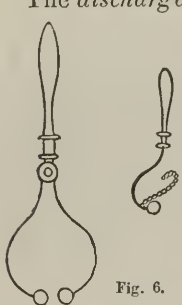


Fig. 6.

to remind you that it is believed that not an atom of positive electricity leaves the glass plate or cylinder that is rubbed, to pass to the prime conductor. The cylinder or plate is rendered positive by friction, and merely acts upon the electricity that is naturally in the prime conductor by induction, decomposing it into the two parts, and attracting the negative fluid, which accumulates in a state of high tension or elasticity, darts off towards the glass to combine with the positive fluid already commencing to be free on its surface, and so reconstituting the neutral or natural electricity. Thus the prime conductor is left powerfully positive, and so all things in contact with it, if also insulated, *not by acquiring electricity from the glass*, but rather by the *abstraction* of its own negative element, while simply *leaving* the positive electricity there.

When charging a Leyden jar, we can judge, after a little experience, how great is the charge from the number of turns of the machine, if we first ascertain that it is working well; but a more accurate means is Lane's discharging electrometer, or by Henley's quadrant electrometer.

To be prepared to use frictional electricity as a therapeutic, we need to be provided with the insulating Chair and Stool. The patient can be placed on the stool, but it is better to place him or her in the insulating chair with the feet upon the insulating stool; or if in bed, by placing the bedstead posts, or feet of the lounge, into thick glass salt cups. The patient thus situated can be *electrified positively* by connecting him with the prime conductor, or *negatively* by the rubber connection, by means of the long discharger, or by means of the chain, or by a large copper wire tipped with balls. By a steady and lively turning of the machine, the patient can be kept at this state for a half hour together, notwithstanding the continual insensible discharge that is constantly going on into the air. If in the dark, this phenomenon becomes visible, as the tips of the hairs and every other angle will appear luminous, or emit sparks even, if approached by a conductor to any part of the person.

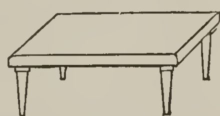


Fig. 7.

When a patient is insulated and gradually charged from the prime conductor *positively* to a high degree of tension, and thus continued for a little while, during this if any *pointed* director is placed near him, the plus electricity is by it drawn off at that vicinity very quietly, and almost insensibly, only giving rise to the phenomenon called *aura*. This acts as a *mild*, but most excellent local alterative stimulus; as, for instance, about the eyes and breast. But if we remove the *pointed* director, and in its place use a *ball*, then the electricity is drawn off from the patient in *sparks*, which produce a pricking sensation, much as if the skin were touched with a pin or needle; and the physiological result is also quite different. This succession of sparks produces much the same effect *locally* as the passage of a gentle voltaic current. The effect of these sparks (which can be made more seldom, long, and powerful, or rapid, short, and gentle, according as the brass ball is made to *approximate*, more or less, to the part) acts as a stimulus of a very peculiar kind; because, as Dr. Golding Bird says, besides the simple discharge, there probably is accumulated and *localized* in the flesh positive electricity, at and near the spot where the sparks leave the body, which is thus maintained in wavering density. The skin soon becomes red, which shows its effects on the capillary vessels and at the roots of the hairs. Drawing sparks from the back of a cat is easily done in dry, frosty weather, particularly if pussy is near the fire, simply by first smoothing her fur with a very warm and dry silk, then lightly stroking the fur in the wrong direction, when she will soon give you to understand that she does not like it. These sparks have an in-working at the moist roots of the hairs, and are of the very minutest quantity, but of the highest possible intensity.

It is well to know that in a room where the friction machine is being worked, every single object in that room is negatively electrified, if the rubber end of the machine is put in connection with the room by means of a trailing chain over the table and floor, instead of being in connection with the earth; and so can they become positively charged by reversing the order.

High-pressure steam can be so directed through crooked tubes

and friction on wood, as to produce a profusion of high tension electricity, that by far exceeds any friction electrical machine. I saw an apparatus both in London and in Paris made expressly for this purpose, called the *hydro-electric* machine. By this not only a patient, but a whole ward, patients and all, could be so situated and maintained by it for any requisite time. But according to my own experience, the utility of tension by insulation is quite limited to a few certain cases and conditions, which will be clearly designated when I come to treat of its therapeutic application for nervous diseases.

Galvanic Electricity and Apparatus.

This term is given to that important form of electricity that is produced by *chemical action.* But probably the most simple example of this kind of electricity is shown by merely enclosing the tongue, for instance, between two different clean metals, from which the current is instantly set in motion, even sufficient to be sensible. This may be proved by any one, if they place a piece of silver or gold on the one side of the tongue, and then at the same time a piece of copper or zinc on the other side of the tongue, or, what is better still, simply a piece of clean zinc on the one side, while there is a piece of clean silver on the other. As long as the metals are so placed and held, there is no taste or sensation; but if now the outer edges of the two metals are brought together, or if by means of a bit of wire they are brought in contact or communication, then instantly there is demonstrated the galvanic action. If this does not readily appear at the first contact, repeat the opening and closing of the metallic contact quick or slow, and it will be decidedly manifested both by taste and sensation.

When two metals are placed in contact direct, or by means of a connecting wire, and when these are placed in a liquid or liquids capable of acting upon the one more than upon the other, then that peculiar electricity is evolved that we term *voltaic electricity*, *galvanic electricity*, or *galvanism.* The original *pile* for producing this current was devised by Dr. Volta, an

Italian physician, owing to the interpretation which this celebrated philosopher gave to the marvellous experiment of his contemporary, Dr. Luigi Galvani, of Bologna, namely, that a frog undergoes a violent agitation, when one of its nerves, being exposed, is touched with one metal, and at the same time its muscles are touched with another metal, while the two metals themselves are in contact.

Volta, and most natural philosophers since him, have supposed that the liberation of the current was entirely due to the *contact* of the two different kinds of metals, whilst the liquid between them plays merely the part of a conductor. To prove this, he invented his pile; and hence the term voltaic electricity. But it has since been proved by the researches of Sir Humphry Davy, M. Becquerel, M. De la Rive, and Professor Faraday, that the real source of the electricity is not from simple contact, but from the chemical action of two heterogeneous bodies; that contact is a condition most frequently necessary, but not always absolutely indispensable to the manifestation of electricity; that voltaic, or otherwise called galvanic electricity, may be produced by any chemical action; not only by the action of some liquid upon a solid, but likewise by the action of two or more dissimilar liquids upon each other; or even by gases acting upon gases, liquids, or solids. All agreed then, as now, that the effect produced upon the frog was due to the action of electricity; and as Galvani was the first discoverer of the phenomenon, this electricity is termed Galvanic, and the physical science concerned in it is called *Galvanism.* But to the pile itself, says De la Rive, must remain the name of its illustrious inventor.

The original *Voltaic pile*, as first formed by Volta, was in the shape of a vertical column, formed of disks of copper and zinc of some two inches in diameter, and arranged as follows: —

A copper disk is first placed upon a glass, or some other insulating plate; a zinc disk is then placed directly upon the copper disk; and then the next disk is of cloth, well moistened with water, salt water, or acidulated water, which is then placed upon the zinc disk. A second similar pair is piled upon the first, a third upon the second, and so on to some fifty or a hundred

pairs; each pair in the same exact order, i. e., first a copper and then a zinc, and each pair separated from the next pair by the wet cloth, and the whole retained in a pile by three or four perpendicular glass rods.


Fig. 8. Voltaic Pile.

This pile is found to be charged with negative electricity at its lower extremity, which is copper, and with positive electricity at its top, which is zinc. The top and bottom ends of this series or pile are called the *poles.* As soon as the poles of the pile are united by a conducting wire, the water that moistens the cloth between the several pairs becomes decomposed, and hydrogen is attracted to the copper, and the oxygen to the zinc. Then by this chemical action there is an electro-motive *force* set in action, which decomposes the natural or latent electricity of the metals into positive and negative electricity, the former accumulating upon the zinc pole in this arrangement, and the latter upon the copper. This pile may be laid down, or turned the other end up, — still is the zinc the positive pole, and the copper the negative. But here let me call particular attention to the *fact*, that this is exactly the *reverse* of what obtains in all our metallic pairs in liquid batteries, — for then the copper is the positive, while the zinc is the negative pole; but this can be easily explained. From this fact not being *heeded* a deal of confusion and misunderstanding has always resulted. The batteries with which we have to do, then, give the most oxidizable metal, which is zinc, as the negative pole; while the least oxidizable metal, which is copper, or silver, or platinum, is the positive pole; but in a moist or dry pile, the reverse is the result. Let these facts be retained.

But to return. If the two poles of the voltaic pile be connected by a conducting wire, then the two opposite electricities travel towards each other over the same wire to neutralize where they started from, which is at the zinc or most oxidizable metal. But as there is a certain continuous supply, there will also be a continuous process or *current* as long and in propor-

tion as the chemical action continues. Hence it results that *the power of this pile is variable;* it begins to diminish from the moment it is laid up, and in a short time it totally ceases,—the copper disks having been covered with hydrogen together with oxide of zinc, from the decomposition of sulphate zinc, while the zinc disks are also loaded with their own oxide. This was a great inconvenience; besides, it gave the widest variety of results.

To avoid this trouble it was proposed to substitute for these disks a *trough* of liquid; and this necessarily converted the arrangement into a horizontal succession, instead of a perpendicular pile. The disks or plates were then to be rectangular, in the place of being circular; each two dissimilar metal pairs were to be in contact, and the whole series to be wedged tightly in the wooden trough, and so adjusted that they formed *cells*, and could be filled with the acidulated water in the trough at pleasure. This improvement was first pointed out by M. Cruikshank, and was then arranged for and given by the Emperor Napoleon to the great Polytechnic School of France. It was with this battery that MM. Gay-Lussac and Thénard, in 1808, made their splendid experiments; yet this cell trough was almost as troublesome as the original pile, but it possessed the advantage of more uniform and greater power *when cleaned* and put together anew for work.

Cruikshank's battery was then improved in various ways, until the cells of the trough were made to receive two plates of dissimilar metals, as before, it is true, but not of the same pair; i. e., one plate of a pair was in one cell, while the other plate was in the next cell, yet so as to be lifted out or put in, so that every cell received a pair of copper and zinc in the same liquid, not in metallic contact between themselves, as in the original, but connecting only with its next neighbor. This is the true arrangement of a galvanic battery as first shown by Becquerel. The author saw the remains of such a battery, which was provided for Sir H. Davy, in the laboratory of the Museum building of the Royal College of Physicians and Surgeons in London. Although only some eight or ten cells were in each trough, yet

such a number of these were provided in connection, as to give him a battery of some two thousand pairs. It was with such ample means that Davy, and, still more recently, Faraday, made their splendid discoveries.

Dr. Wollaston found that the effect of this battery was still further augmented in power, for the same number of cells, if there was a greater surface given to the copper than to the zinc. This double-sized copper characterized the Wollaston battery.

Berzelius then demonstrated that if, instead of using a wooden trough, the copper itself be made into cells, or cups, so as to hold and envelop the zincs, but without touching, this would enhance still further the excellency of the battery. Such galvanic arrangements were for many years exclusively used for all experiments and practice that was ventured upon; but they all possessed one great inconvenience; and that was, that after a very *short* time they lost their power, and finally would cease to act, until they were cleaned and replenished.

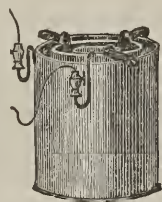


Fig. 9. A Berzelius Battery, separate from the Induction Helix, — commonly called the "Copper and Zinc," or Sulphate of Copper Battery.

To avoid this, M. Becquerel proposed to plunge *each* of the metals into a *special* liquid, — being separated from each other by a porous diaphragm which would conduct and allow a communication between the two liquids. To that end he constructed a battery in a glass jar; he then placed in this vessel a cylinder of zinc, closed at its bottom like a deep cup. In the space between the glass jar and its contained zinc cylinder he placed the acidulated water; but in the interior of the zinc was placed a bladder, or piece of intestine, which contained the copper, together with a strong solution of the sulphate of copper. When the poles of this battery are connected, both the water and the solution of sulphate of copper are decomposed by the electro-chemical action; one part of the oxygen liberated combines with zinc to form oxide of zinc, which at once combines again with the sulphuric acid that acidulated the outer fluid to form sulphate of zinc, while another part of the oxygen com-

bines with hydrogen to form water. Besides this, there is a thin film of copper deposited on the surface of the within copper. Now, it is easy to see that Becquerel's battery would work more slowly, but far more constantly than the voltaic pile or any other battery then known. But the organic membrane was not, after all, very durable; and this was the greatest objection to this otherwise valuable battery.

The *Water battery*, as it is called, came next. It was first prepared by M. Gassiot, and is peculiar for possessing properties of but feeble dynamic electricity, as compared with its static accumulation and tension effects. This is indeed the characteristic also of all so called *dry piles*, which give an electricity in a state of tension alone. M. Gassiot employed glass cells, which were supported upon glass columns so as to render the insulation more complete. Thus he constructed a compound battery of 3520 zinc and copper pairs in as many cells, which were charged only by pure water. This, says M. De la Rive, during the several years it has remained set up, at all times gives electric sparks at each of its poles, (which are also insulated.) The only precaution taken with this apparatus, is to pour water into the cells occasionally, so as to replace that which is lost by evaporation. In this case, it is the air that is contained in the water that oxidizes the plates so slowly or minutely, that it thus lasts and acts for years together.

The *Dry pile* is constructed much as Volta's original moist pile; but it is not an absolutely dry pile after all, for in that case it would not act. To prepare the permanent dry pile, large, stout sheets of brown paper are coated on the one side with tin foil, which answers to the place of the zinc in other batteries, and the other side of the paper is coated with the peroxide of manganese, which answers to copper. The paper is first tinned on one side only; on the other side the manganese is spread by means of a soft brush. The powder of peroxide of manganese is prepared in a fluid paste and milk. When the sheets are dry they are cut neatly in squares for disks. These are then laid in the same order, the one above the other, so that a face of tin and another of manganese may always be in contact in all the

layers; while between every pair, or two such leaves, there may also be placed a blank sheet of the paper, and thus hundreds, or even thousands, may be built up to compose the dry pile. But the paper evidently gathers a minutia of moisture from the atmosphere, and this is the acting agent. This pile, being built upon an insulator, terminates at its top and bottom with the opposite kinds of metals; the tin is the negative pole, while the manganese is the positive pole. This pile cannot yield any very appreciable current, and yet it will for years give small sparks between its poles at any time. This shows its peculiar polarity, or tendency to *accumulate* tension electricity at its extremities or poles.

In 1836, Daniell conceived the idea of trying various durable partitions to separate the two liquids, as Becquerel had been trying to do. He placed the copper of each pair in a solution of the sulphate of copper, which occupied the larger outer space in the jar, while the zinc was placed in a solution of salt and water, or acidulated water — say sulphuric acid one part, to water twenty parts, or in sea water. He made some diaphragms with felt, some of stout paper, others of very thin wood. Experience gives the preference for a kind of porous *porcelain*, that is durable and yet slowly transmits the liquids for action upon the metals.

In the inner cell, then, — that is, within the porous cell, — he places the zinc in a solution of salt and water, or acidulated water; but the zinc is first coated with quicksilver, which prevents its being attacked *while the poles are not* united by a conductor, and so without diminishing the effect of the battery *while not in use.* But it will be perceived

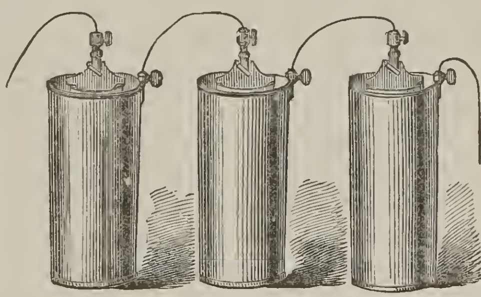


Fig. 10. A Series of three Daniell's Batteries for Galvanism, showing their Connections.

that the decomposition that is brought about is the same as in Becquerel's.

The next improvement made in the galvanic battery was by Grove; and his is one of the most *powerful* that has ever been constructed. In this battery a small plate of platinum takes the place of the copper, and a strong solution of nitric acid is used in the place of the solution of sulphate of copper. The amalgamated zinc is plunged into a strong solution of sulphuric acid, which is contained within the inner cup of unglazed or porous porcelain. The zinc is amalgamated, or covered with a coat of mercury, by dipping it into a vessel containing a strong solution of sulphuric acid with quicksilver, or by pouring these on the plate, and then brushing it with a tooth brush until amalgamated. Thus the surface of the zinc is cleared by the acid, when the mercury will readily adhere and coat it. In this arranged battery, the nitric acid has the double advantage of containing much oxygen, which first increases the intensity of the current; and second, being a better conductor than the solution of sulphate of copper, it transmits the current through the batteries more readily. Here the hydrogen is not developed upon the platinum, but changes the nitric acid into nitrous acid, and the liquid therefore becomes of a brown color, and then soon passes into a green color, while the surface of the platinum always remains the same — that is, clean. The zinc is oxidized, and sulphate of zinc is found in solution. But after a certain time, this furious battery is fairly *self-arrested* by the further changes which are going on so rapidly in the nitric acid, resulting from the development of hydrogen and heat, until the acid actually enters into ebullition at last, and like the back water of the flooded milldam stops action because there is so much action. In this stage, it is absolutely necessary to stop the action immediately; i. e., to take it apart in order to save the battery.

Bunsen's battery is another powerful apparatus for particular purposes, and this differs but little from Grove's, only as *carbon* is substituted for platinum. It was formerly found that platinum was more negative than copper, that is, still less attacked by the liquid; so is carbon still more negative than even plat-

inum, besides being very much cheaper. In the original Bunsen's battery, there was arranged a cylinder of baked carbon, *open* at its bottom and placed in the glass jar, within which was a porous diaphragm of pipe clay, which contained the zinc and dilute sulphuric acid, while dilute nitric acid filled the jar about this large body of carbon. But this has lately been improved, so as to dispense with the porous diaphragm altogether. The author has seen some of these improved *carbon cups*, with *closed* bottoms, so prepared by T. Hall, for the professor of chemistry at Harvard. Some five or six cups produced a heating, chemical, and decomposing power, equal to fifty cells of best Cruikshank's. In this case the carbon cup is fitted with dry, powdered carbon, and moistened with nitric acid. For cauterizing, this is the battery, as it possesses the most tremendous *quantity* power; but it does not last very long in action, nor is it required to act long for such purposes. (See page 659.)

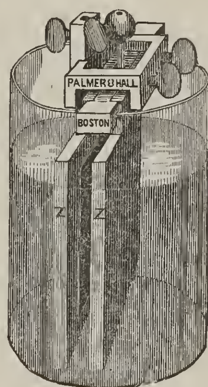


Fig. 11.
Smee's Constant Battery.

Smee's battery is the most clean, and one of the most permanent and economical arrangements we know of. This is arranged in a quart or half-gallon glass jar, by mostly filling it with water acidulated by one tenth or one fifteenth part of sulphuric acid. Into this are plunged two flat, square plates of zinc, say four by six inches, and one half inch thick, and coated with mercury, which are suspended from the top. Between these there is arranged the thin plate of platinum or platinized silver. This apparatus can remain in working order for a month, but if much used should be overhauled once a week; that is, the zinc plate should be new coated with quicksilver, and if that is well attended to, for dentists and other office use it will wear a year or more.

Daniell's battery is now so improved that it is the most perma-

nent and even-working galvanic battery known, and for medical purposes it is invaluable, particularly for the so-called *constant galvanic current.* The arrangement is in large, strong quart glass jars, by using porous diaphragms of pipe-clay cups. Within this porous cup is the solid pound of zinc, say an inch or so in diameter and some four inches long. Then a bit of sheet copper, say four by six inches, is so rolled and bent as to just drop inside the glass jar, and the jar is then packed nearly full of crystals of sulphate of copper. Indeed, it is better to bruise the sulphate a little in a mortar, so as to work it in without getting it also inside of the pipe-clay cup. The copper is thus buried in the sulphate, and the zinc is placed within the pipe clay; then the whole is filled to within a half inch or so of the top of the porous cup with water. It is better not to fill the inner cup quite as full of water as the outside of it is, for this will allow the battery to get at work within a few hours. Some thirty to fifty of these cups connected *consecutively* form a battery sufficiently powerful for any remedial purposes, and yet, if well managed, will so run for a year in good working order without replenishing except with water. In fitting up this battery, I find it very advantageous to place a strip of stout brown paper or *oil-cloth* about the tops of all the cups, *to prevent* the capillary attraction in the re-crystallization of the sulphate driven on by the process, from running over the outside of the glasses. This has caused me a deal of trouble, as, in the course of every few months, we would find great quantities of the copper solution crystallized all over and between the glass cups; but by pasting strips of rubber cloth tightly and carefully around the tops of the cups, so as to be some half inch above them, it will stop it; (for these cups are without lips or rims,) and then the paper should be varnished on the outside. This appears to be the most effectual means I can find to prevent this dirty and wasteful inconvenience. Some one hundred and seventy cups thus prepared have been running now nearly a year in my office, and they have only been replenished with water every three months; and now they are as clean on the outside as at first, without exception.

To sum up, then, I can say from my own experience in electro-medical practice, I find that *for constant galvanism* the Daniell's battery, or Garratt's battery is the best, because of the moderate, *uniform*, and long persistent action.

For *cauterization*, and all those operations where we require a quick white *heat* and rapid chemical decomposition, the Bunsen's battery, improved, is for this purpose the best; but twice or three times the number of Grove's batteries will answer well.

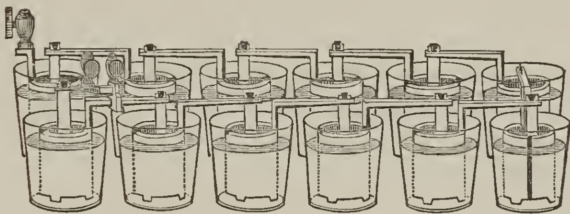


Fig. 12. A Series of Grove's Batteries in a Box, 12 in number.

For producing the common *induction* current of electro-magnetism, *Smee's battery*, as heretofore described, is the cleanest and most persistent, and for these reasons the best; but the *copper cup*, with its large zinc cylinder, that is run with sulphate of copper or blue vitriol, which is indeed the Berzelius battery, and more extensively used in our country than any other, answers very well; only it is to be taken apart every time it is used, and it is better still if it is also thus often cleansed. Therefore, for these purposes, I should prefer the friction plate machine for static electricity; Daniell's or Garratt's battery for galvanic currents; Bunsen's or Grove's batteries, as improved, for the heat and decomposition; Smee's, or Berzelius's battery, for Faradaic currents.

Humboldt Battery.

This is something new, although the *principle of its action* was known to the great Baron and philosopher nearly seventy years ago; but the term *Humboldt battery* originates with the author. The convenience and usefulness of this very cheap, portable, durable, *and least troublesome of all galvanic arrange-*

ments, and for its very peculiar adaptation under frequently recurring circumstances, for the treatment of a given class of cases, must (as it becomes better known, judging from experience) always gain for it a prominent place among the more *practical and reliable* of our best electro-therapeutics. For these reasons, too, the author has interested himself, through no small pains and expense, to procure its present improved arrangement and structure for greater and more uniform efficiency; and with him also originates the first methodical and substantial manufacture of this useful little article for physicians' and surgeons' use, so that it can now be provided at slight expense, and yet is as reliable as it is portable and durable. It is in fact a part of

Garratt's Medical Battery,

which is a new combination, a portable arrangement, of old galvanic and voltaic principles, yielding only a *primary* current, and is admirably adapted to very many *medical* purposes. It is, in effect, two batteries in one; that is, one is simply a "*quantity*" current, or, in other words, is without intensity; while the other is a graduated "*intensity*" current. It can be used separately, for certain cases, or double and compound for others; while the thing is peculiarly *portable*, *clean*, *easy to use*, and *durable:* a wine glass of vinegar is sufficient to put the whole in full action, as its power depends upon the nice "*contiguity of metals*," and not on the *amount* of chemical action. Out of a Garratt's battery, thus can be arranged, at any moment, a Humboldt battery, and each as complete when separate as when together; and in the same box suitable electrodes, &c., are provided, with directions how to apply the different primary currents. The whole might be easily deposited in the drawer of any portable electro-magnetic boxed battery; and this would make a physician's *electric armamentarium* complete, with all varieties of primary and secondary currents for medical purposes, as nowhere else to be found.

Garratt's battery, therefore, can be carried to the bedside, and speedily adjusted, for producing the most gentle and

*in*sensible *primary current of galvanism;* or graduated to any degree of *intensity*, even to one hundred elements. And from this one hundred there appears to be obtained quite as much *physiological* effect, and *curative* power, as is produeed by the ponderous Daniell's battery of fifty elements in quart jars. That is, the fifty or one hundred elements of Garratt's tiny battery, when used either single or double, will aecomplish, in ten minutes, about the same that twenty-five to fifty of Daniell's will do in five minutes. Thus, element for element, in these two battery arrangements, the latter has about twiee the inworking power, when compared with the former. But the Daniell's eosts five times more than the Garratt's; besides, Daniell's battery is immovable, while Garratt's battery is so compact and elean that it may be earried in the eoat poeket, and is always ready for action. The former is best for office and speeial praetiee; the latter for the praetitioner's bedside use. To elearly understand the double or twofold aetion of a *Garratt's primary medical battery*, as a whole, let it be laid stretehed out upon the table, but eoiled a little, so as to form a large segment of a eirele, as seen at page 154. Thus lying, the poles, or zinc and silver pads, are seen to be a little separated from each other. Now, when any portion of the moist flesh of the human body or limb is embraced between these *poles* or *plates* of dissimilar metals, the eircle is closed and eompleted, so that the electric current instantly begins to eireulate in a given direetion. If, now, the *power-coils* should be unhooked, and the insulated conduetor be directly from silver to zinc, (leaving out the *power-coils*,) the current is from the zinc through the flesh to the silver, and baek again through the insulated eonductor to the zine; so that *the zinc pole or plate in this arrangement is the positive pole*, while the silver is the negative. Therefore, in order to have the eurrent of the *power-coils* work in the same direetion with the former, the terminal zinc strand of the power-coil *must connect with the silver*, while the terminal strand of copper, at the other end, eonnects with the zinc plate. This is important. If, now, the whole is lifted from the table, with one pole in eaeh hand of the operator, the *power-coils* can be thoroughly wet

with vinegar, or vinegar and water, by carefully and gradually drawing them through the liquor (in a cup or saucer) from left to right and from right to left, as seen at page 154, until quite sure that *every* coil is saturated. If but one coil should fail to be wet, the current will not pass, because the metals are there insulated by the dry wood. The battery is now in action, ready for work, and will continue to work *as long as the wood in the coils remains wet*, which is about one hour. If required to be used longer, it must be re-dipped in the vinegar. When the work is done, the coils should be washed in clean warm water, (no soap;) and if still more cleaning is needed, the occasional use of an old nail-brush or tooth-brush in the warm, fair water, is all that is required. When the silver and zinc plates are used without the power-coils, and are covered with oiled silk, or so bound on as to retain the perspiration about them, they act *perpetually*, day and night, if required. This action is increased if the skin is wet with salt and water. These plates must be kept clean by using whiting for the silver, and sand-paper or soap and sand for the zinc plate. The contacts or hooks must all be clean and free from grease.

Thus in the circle of the combinations of a Garratt's battery there are two *sources* of electric power: the one is the flesh itself that is between the silver and zinc pair; the second is the series of power-coils on the opposite side of the circle. These power-coils, moreover, which are made, in some respects, like the links of a Pulvermacher's belt and chain, can be employed without the zinc and silver pair, as for neuralgias, rheumatisms, and wherever sponge electrodes are indicated. But where shocks or broken currents are indicated, as for *atonic* debility, local palsy, &c., then, by disconnecting one of the hooks or clasps of the insulated conductor, and still holding it near by, we can make a series of repeated contacts, or retain them at pleasure.

This little battery can be worn by the patient during the day or night, at work or during rest. It can be carried in the vest pocket of the physician, and is always ready for action. With it we can effect mild shocks by simply disconnecting the clasp,

and then making repeated contacts. The current can be made *very active* by wetting the two pads with salt and water when applying them; or, if applied dry, the constant current begins gently, and flows continuously. It can thus be employed so as to be as varied and active on living tissues as the *primary* current of the electro-magnetic machine; and thus much efficient work can be readily done by it. But it is in the hands of the busy and hurried general practitioner of medicine that this "*multum in parvo*" of an electric machine can be subservient to the greatest number and variety of purposes, rather than for the special practitioner. The particular cases for which this is indicated will often be specified, but more usually they must be decided upon from general principles. (See Chapter V., also page 475, and the Appendix.)

Pulvermacher's chain, (better known in Europe,) is a very remarkable miniature voltaic pile. The *pairs* of this consist simply of a piece of hard wood, around which is coiled a zinc wire, that terminates at one end with a hook or eye; and then there is coiled between the zinc coils a brass wire that terminates at the other end of the link in the same manner. This forms an element. These are linked together like a chain, the brass end of one into the zinc end of the next, and so on for sixty or one hundred and twenty links, which terminate with a brass buckle and belt at one end, and a silver plated buckle at the other, for fastening it about the body or limb; or, according to Pulvermacher's directions, "Apply the gold buckle over the spine, and the silver buckle over the seat of disease." Besides, there is a clock-work for breaking the current, &c. But this voltaic principle, for economy, correct as it certainly is, becomes a failure in practice—first, because of its frail construction; second, because of its electrode arrangements being intended for empirical application, rather than for scientific and skilful manipulation.

The *Electric Moxa* of Dr. Golding Bird is admirably made by the Humboldt battery, heretofore described. He advised the making of two blisters, by blister-plaster, in the ordinary way; the one above, the other below, the spot that is to be affected.

The silver plate is to be placed upon the *lower* denuded blister, while the zinc plate is planted also over the upper denuded blister, when the connecting wires from each are brought together, and twisted into secure contact. But the joined conductor must be perfectly insulated from the skin and wet cloths. The blister, over which the zinc plate was bound, is found, in the course of a few hours, to be coated with a whitish-looking film, as if the chloride of zinc had been applied to it. In forty-eight hours an eschar is produced, which begins to separate some four or five days afterwards. The eschar is produced by the chemical action of the continuous current in decomposing the effused fluids on the surface of the blister. The chloride of zinc thus gradually formed, and as gradually applied, by the electro-chemical action, produces the new sore that will now freely discharge pus when a common poultice is applied to it. While this process is going on the patient is *usually* quite free from pain, but the author has known some decided exceptions. Where it does prove painful it had better be at once removed, for after a little time it can often be reapplied without the suffering. Dr. Bird advises the blisters to be the size of a half dollar or dollar, and to always apply the *zinc plate* (which is of the same size of the blister) *nearest to the head of the patient*, while the silver, which is the same size, is *farthest* from the head, and nearest the extent of the extremity, as, for instance, of the hand or foot. Over each plate, water or salt-and-water dressing is applied, and, above this, oiled silk or rubber cloth, merely for the purpose of retaining the moisture; while flannel or warm clothing covers over the whole.

Recamier's galvanic poultice has been found useful for rheumatisms, lamenesses, weakness, amenorrhœa, &c.; but it appears to be much like the old voltaic pile, valuable for only a short time, and is soon corroded and exhausted beyond any efficiency. This consists of pieces of cotton wool, which contain ribbons or minute pieces of zinc and copper, each pair being separated by flannel. The cotton is placed in a bag, the one side of which is made air-tight, i. e., of oil cloth or rubber, and the other side or half of the bag is made of cotton cloth. The permeable or cot-

ton side is a little moistened, and then applied to the skin over the seat of trouble, and retained by a roller. It is soon saturated with vapory moisture, from perspiration, and this sets in action the automatic pile. If vinegar is used to moisten it, greater and quicker effects are produced, but then they are of shorter duration. There is, however, the highest professional testimony of the great service these *electric poultices* have given in difficult cases of local weakness and pains.

Galvanic cautery requires particular electrodes, as well as *quantity* current. There is an instrument invented by Mr. Ellis, of England, for galvanic cauterization of the cervix uteri, and other deep tissues that require the concentration of the continuous heat produced by a galvanic battery. This instrument consists of a silver catheter straightened out, with the end cut off. At the upper end of this catheter-like tube, it is slit open and broached so as to form a socket for the *tip of porcelain*, which is the cauterizer. Two conducting wires, adjustable with the poles of the battery, are insulated through this silver tube, and their free extremities are connected with a piece of *fine platinum* wire, which is now coiled around the little sugar-loaf-shaped porcelain, in order to render it completely incandescent. The porcelain must be heated by the adjustable pole *contact*, and maintained at a white heat. For this purpose it will require some five or six Bunsen's batteries of one-gallon jars. One or two dozen of Grove's batteries of quart size will also do it. But, whatever battery is chosen, the metal pairs must be of a large size or surface, with a strong and active solution, so as to yield the larger and higher degree of chemical action, by which we can have *quantity*, and also some considerable *intensity*. I have found that from six to ten Grove's batteries, (such as Mr. Hall gets up in cases,) are quite sufficient to heat small platinum wires, and maintain them at a white heat during the smaller operations. Yet it is always well to have at command all the heat the platinum tips will bear without melting. This should be first tested, *invariably, before making contact with the flesh*, so as to adjust the right degree of heat to insure success and safety.—(See pages 155 & 659.)

The galvanic loop, point, and other shaped cauterizers for surgeons' and for dentists' purposes, can be had of the medical electrical instrument maker, Mr. Thomas Hall, 13 Bromfield Street.

Galvanometer.

For all the nicer tests in the study of electro-physiological phenomena we are depending upon the Galvanometer-multiplier and the Galvanoscopic frog. The former is delicately constructed by our electrical and philosophical instrument makers. But the latter requires precautions that are to be remembered in preparing it afresh from time to time, as it must be done. First, the frog must be fresh caught and vigorous. The leg must be of very recent amputation. Care must be taken to preserve and separate the ischiatic nerve as long, and with as little handling, as possible. The leg must then be perfectly insulated. We must close the circuit of the experiment with the nerve alone, carefully avoiding any touch of the muscles, so as to not include any of its influence. The pendulous nerve, fresh and moist, must alone be touched in two places by the two points that are suspected to be the poles of the electromotor element that we desire to study. If all is thus correctly done, the leg is then seen to contract instantly, if any such force is found. Also, with a very great degree of certainty, we may determine the *direction* of the current. For this end we choose a frog's leg that is become enfeebled a little, and thus some less excitable. If, now, the current is brought to bear upon its nerve, in a direction *up-running*, i. e., from the leg towards the cut end of the nerve, we see the contraction at the *instant* the current is closed. On opening the circuit it is motionless. But if the current is directed so as to course the nerve of the prepared leg in a reversed or *down-running* direction, then the reverse obtains — i. e., motionless on closure, but contraction on opening.

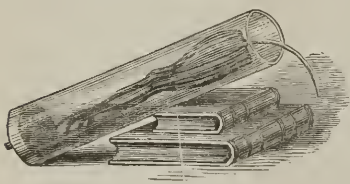


Fig. 13. Galvanoscopic Frog.

The employment of the Galvanometer instrument for accuracy and delicate purposes also requires the utmost precaution. It is necessary, first of all, to *avoid* any chemical action, even of the animal liquids, upon the platinum plates, which serve to bring into the circuit the various organs or tissues whose electric

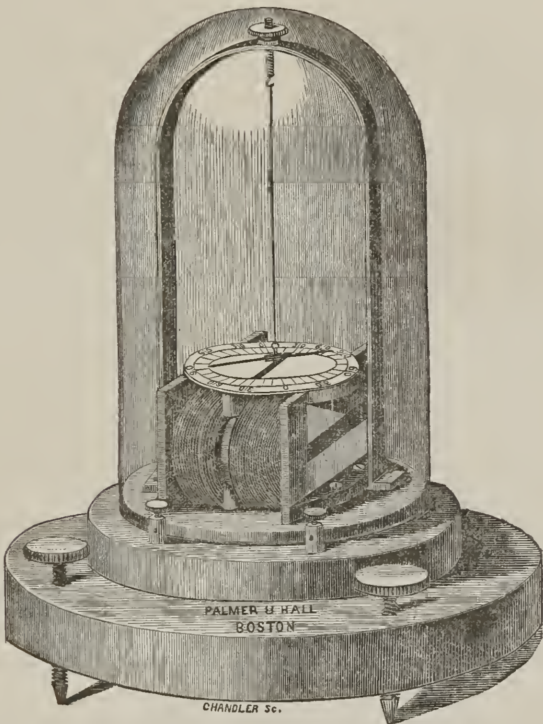


Fig. 14. Galvanometer.

state we are studying. To this end we must use pure platinum plates of equal size, cleansed with exact care. Then we must even allow them to be plunged into pure water for some time, to prevent the simple immersion from giving rise to some current, as it is so liable to do. When thus quite sure there is no action, we then touch at the same time, with these two poles insulated, the animal parts to be tested. But the mere fact of the circula-

tion of a current polarizes the plates, and renders them afterwards capable of producing, without any other cause, a delicate secondary current. For this reason, we should never attempt to test twice consecutively, without first taking care to depolarize the plates thoroughly, by placing them in pure distilled water for a time, while they remain in metallic communication.

Static Electricity as it relates to Medicine.

We now know that we cannot classify all bodies into *perfect conductors* of electricity, and into *perfect insulators;* or, in other words, we cannot say of silk or metal, that the one never conducts in any case, or that the other conducts perfectly well under all circumstances; therefore the *term* electric conductibility is not absolute. The metals are almost perfect conductors; yet they present among themselves, as we have already observed, a difference in degree of conductibility; also the same metal or body conducts better or worse, according to its *dimensions* and its *temperature.*

Generally we call all bodies *electrized,* whatever they may be, which have been put into communication with an electrized body; but strictly so speaking only when they thus show an attraction at a distance upon light bodies. Therefore in Static Electricity we are taught to observe, —

1. That there is an *attraction* between an electrized body and one that is not electrized.

2. That there is *repulsion* between two bodies electrized by the same source of electricity.

3. That there is an *attraction* between two bodies electrized, the one as by glass, and the other as by wax; glass acquiring by friction *vitreous* electricity; wax acquiring by friction *resinous* electricity; the former, or vitreous, is termed *positive electricity;* the latter, or resinous, is termed *negative electricity.* When these reunite, and neutralize, either through the air as a spark, or insensibly, or through a conductor, the electricity is then said to be in the *dynamic state;* i. e., during the *instant* that this marriage is going on. This is also termed the *electric discharge.*

To be understood, this denomination of *dynamic* is given to that state of movement in which the two electricities are supposed to be, when travelling towards each other to neutralize, in contradistinction to the *static* state, or that of rest, as where these two different electricities are found when they are separately accumulated, on insulated bodies. This latter state is also called *electric tension.*

We see, then, that dynamic electricity may be only *instantaneous*, or it may be *continuous.* In the preceding case it was instantaneous, and done. But suppose one ball to be in communication with a constant source of positive electricity, while the other ball is connected with an equally constant source of negative electricity; the two electricities being constantly renewed as fast as they are neutralized, there will be a continuous succession of sparks, if the balls or electrodes are brought only close together; but if so as to touch each other, then there will be between the two ball electrodes a continual, uninterrupted neutralization, or, in other words, a continuous reunion of the two electricities. This is denominated *the continuous dynamic state*, and also called the *electric current.*

Electric Conduction.

The property which is possessed by most bodies, and by metals in particular, of more or less readily acquiring and propagating through their whole extent the electricity that is possessed by that part of an electrized body with which they are in contact, is termed *electric conduction*, and such materials are called *conductors.* Those which do not possess this property are called *insulators.* The human body, ordinary wood, animals, vegetables, and most minerals are conductors; while amber, wax, glass, baked hard wood, fur, gum-lac, resins, and a majority of crystals, as also silk, oil, rubber, and gutta percha are *non-conductors*, or, in other words, are insulators. The earth is our largest conductor; the vast extent of atmospheric air over its surface, when dry, is our largest insulator. The *diamond* is the most perfect insulator, while *silver* is most nearly a perfect conductor.

The conductibility of bodies for electricity, which are so reckoned, is not, however, an absolute property, for there is every grade of difference observed in different bodies; and these even vary in themselves at different times. Water is a conductor, but *dry* ice is a good insulator. Glass is reckoned a most excellent insulator; but if it is damp, or is drawn out into a slim rod, or is heated to redness, it becomes a good conductor. Wax and tallow become conductors by melting them; but the metals, on the contrary, *do not* conduct so well when they are heated.

The dry atmospheric air, being an insulator, prevents electrized bodies losing their electricity. Were the air a conductor, it would cause the electricity of every insulating body to be dissipated into the whole mass of the atmosphere, as does contact with the earth. This does take place when the air is moist, or where the apparatus is colder than the air. Therefore it is necessary to have a dry atmosphere, and a machine free from humidity, to make experiments or practice succeed well with friction electricity.

It is necessary to be mindful, that, if any electric current of a given quantity and intensity is made to pass through several different wires, of the same sample of metal and make, and same diameter, but of different lengths, we shall see that the current loses power in proportion to the length of the wires tested. If, now, the current is made to pass through wires of exactly the same metal and length, but of *different diameter*, the power is greater in proportion to the diameter of the wires. For instance, a copper wire that is a hundred feet long and the tenth of an inch in diameter, will offer the same amount of resistance as another copper wire that is two hundred feet in length and only one fifth of an inch in diameter. The conductibility of bodies, therefore, does not depend upon their chemical nature only, but also upon their *form*. Nor are there any absolutely perfect conductors of electricity. Indeed, it may be said that *all bodies* through which a current may be directed offer a certain greater or less resistance; and hence diminish its intensity according to their chemical nature and form.

If a galvanometer be placed between the shortest poles of a

voltaic battery, we see the astatic needle deflected to a certain degree by the passing current. If we now lengthen the conductors by interposing copper or even silver wire of a given length, and then again of twice that length, and then again of twice the length of the latter, we shall find from these experiments, that the needle of the instrument is less and less deflected, according to the length of the conductors, although of the very best material. The human living body conducts all electric currents ten to twenty times better than pure cold water. This is supposed to be on account of the warm salt water it contains. But I am more and more inclined to believe that this is owing to the arrangement of these different fluids in the different cells and tissues of the living organism, which are separated only by the thinnest membrane, and being provided with nerves, not only have a *tendency* to electric action, but possessing an *actual*, *perpetual* minute action, which, to my mind, serves for the artificial current conduction, much as Professor Morse's registering battery helps the working of the wires; perhaps more, as the aurora borealis helps the conductibility of the telegraph wires.

The epidermis is, in this case, probably, the greatest hinderance to all currents of electricity; but this can be greatly counterbalanced by *wet* electrodes. There is an absolute difference in the conductibility of different persons, and even of the same individual at different times. In a group of persons, a single one may be struck by lightning, while all the others remain untouched. But this is not as yet satisfactorily explained. The human body, then, after all, is not in effect a good conductor of electricity, as can be proved by the galvanometer. To test this, the resistance is first determined of the given entire circuit, of say a bearable, but appreciable battery, such as twenty to thirty Daniell's elements afford, by bringing together the two poles in good contact, including nothing but the galvanometer. The degree of resistance from the connecting wires of the batteries, the conductors, and the instrument together, as marked on the dial, is first noticed, and taken for unit or zero. Then the limb or individual is interposed between the wet electrodes, which

must have large and complete contact. Let this be repeated first without, and then with the interposition of the portion of body to be tested, and a very exact relative degree is obtained of the resistance of that given organism.

Direction of the Current.

In the original *voltaic pile*, the positive pole, we have seen, is at the top of the pile, which is zinc; while the bottom of that pile is consequently positive, which is copper. This *law* holds good with all dry, or moist, piles and batteries; as by the law of electro-motive force, positive electricity is driven from the copper to the zinc, and hence the zinc is forced to be positive and the copper negative. *But, mark — this is not true* of our ordinary liquid batteries; for where the metals are plunged into separate vessels, as is the case in the constant batteries, the direction of the current is exactly the reverse. In these batteries, *the positive current travels from the zinc* through the liquid of the battery to the copper, and then from the copper to the zinc of the next pair, and then through that liquid to the copper there contained, and so on through all the series of pairs in the cups or jars of the compound battery; so that the copper is always the positive pole in these constant batteries, and the zinc of course is the negative pole. This is even so in a Berzelius's or a Smee's battery, where there is a single pair in a single liquid. Therefore, in the Berzelius's and Daniell's batteries, the positive pole will be formed by the copper; in Grove's or Smee's batteries, by the platinum or silver; in Bunsen's battery by the carbon; while the zincs form the *negative pole* in each and all of these batteries.

To fully appreciate the kind, nature, and difference of battery or chemical electricity, and to have a rational view of these currents, we must set out with this *law*, namely: where a liquid attacks a metal, the liquid becomes charged with *positive* electricity, and the attacked metal becomes *negative*. The positive of the fluid is at once taken and conducted by the less oxidizable metal that is plunged in the same, and thus conveyed along the conducting wire, back to the oxidizing negative plate in the

battery. If a vessel is nearly filled with acidulated water, and into it we plunge a plate of very oxidizable metal, such as zinc, for example, and also another plate that is much less oxidizable in that liquid, as platinum, and then we unite the two dissimilar metals merely by means of a wire brought up out of the liquid, then the positive electricity that is acquired by the liquid, from the effect of the chemical action, is able, by traversing the connecting and conducting wire, to return and reunite with the negative electricity that the attacked metal has retained. For thus the greater portion of the two electricities, negative and positive, become neutralized through this peculiar process and order, instead of taking place locally, directly at the place of contact of the liquid with the metal that is oxidized, and which Faraday has termed *local action*. Here, then, we see the *rationale* of the electric current or *stream* of the battery with which we shall have so much to do. And this peculiar association or relation of any two dissimilar metals in a liquid, whose power for oxidization and conduction is peculiarly or exclusively for one of the metals rather than for the other, is termed a galvanic pair or battery; and when a number of these are connected, they are then termed a *pile*, or so many *elements*, or a "*compound battery*."

Philosophers teach us that we may also regard the two metals of any voltaic or galvanic pair as separately, but mutually, giving rise to two opposite and unequal currents, one of which — and it is always that arising from the metal most attacked — is the more intense, while the other, arising from the metal least attacked, is the more feeble; that each of the two metals also serves as a conductor to the current of the other. The current, then, that is accumulated is the difference between the two partial and unequal currents, as they would be perfectly null if these two opposite and simultaneous currents were absolutely equal — a condition, as M. De la Rive says, next to an impossibility, even if we employ two metal plates as similar as can be in every respect.

It is, therefore, a *law that the metal of the battery that is most attacked determines that current direction.* But while we attempt to establish in our minds the *first fact*, that the

metal most attacked is the *positive*, and the *second fact*, that the metal least attacked is the *negative*, we must not lose sight of the *third fact*, that the positive electricity comes out of the battery by the negative or copper metal after having passed through the liquid of the battery, and consequently the other, or *negative* electricity, comes out by the positive or zinc metal, so that in these batteries the *zinc pole is negative* while the *copper pole is positive.* Besides, we should take the terms *positive* and *negative* simply in the sense of *electro-motive power,*—the positive as predominating over the negative, and constituting a prevailing stream or current. But we must also recollect, that although it is true that the metal most attacked is the starting point for the current direction, yet the mere galvanic series of metals do not of themselves and under all circumstances determine the route of the current *absolute;* for this is likewise dependent upon the *nature of the liquid* that is employed as an exciter or oxidizer. Faraday found a very curious and interesting *variation* of the current when he placed a galvanic pair of copper and silver in a solution of sulphuret of potassium; the current first setting out from the copper, the silver is not the least tarnished, and soon the action dies down to a low degree. But this is soon seen to be followed by an increasing action that is now on the silver, which gives rise to a current running in the opposite direction, while the silver is becoming more and more coated with the sulphuret; and at the same time the film that was at first formed on the copper is as rapidly dissolved off; in a few minutes more and the needle of the galvanometer drops to near zero, but as soon again begins to rise, reversed, showing an increasing but changed current direction, and the copper again becomes positive, and coats over. Thus the chemical action and the direction of the current change simultaneously.

Quantity and Intensity.

Electricity, when in the current form, has two very distinctive and important characteristics, which must never be unheeded or

confounded. I refer to *quantity* and *intensity*. There appears to be no actual relation between the vivacity of chemical action and the preponderating intensity of electric signs. From this it does not follow that the *quantity* of electricity that is set free is not in relation to the given chemical action. On the contrary, these two respective quantities are in exact proportion to each other. Then it is rather the *nature* of the chemical action than the vivacity of it that determines the characteristic of *intensity* in the given electric manifestation. There cannot be intensity, however, without some degree of chemical action; but the amount of such action graduates the amount of electricity: because this kind of electricity possesses the characteristic property and power of overcoming a great resistance, it was therefore first termed by Faraday electricity of intensity, in contradistinction to electricity of quantity.

These two different forms of electricity from the various galvanic pairs have very different physiological effects, and therefore require to be particularly observed in all therapeutic employments of the current. How, then, can this intensity of the galvanic current be reënforced without a corresponding increase in the quantity? One way to do this is by simply *adding similar pairs in succession, and so connecting them that the positive of one is in metallic contact with the negative of the next*, and so on through all the series, no matter how small or great the number. M. Gassiot, by a series of most remarkable researches with his *water battery* of 3520 galvanic pairs insulated, discovered in this connection, that the more powerful the mutual affinity of the elements that compose each battery, the less number of such are required to produce the same great effects of tension. He found, by well insulating one hundred of Grove's batteries, a *tension* accumulated at the poles quite equal to that of the whole water pile of 3520 pairs. But to test the *relative* tension of such an arrangement, that is, with the same given deviation of the galvanometer, it is necessary to use the electrometer to detect directly the tension, or by using the rheostat to detect the amount of resistance that is overcome.

The law of electro-chemical equivalents of a single galvanic

pair was first pointed out by Faraday. M. Matteucci next gave the equivalents for a pile or series of batteries, by using as a good electrolite a solution of the sulphate of eopper. If the battery, for example, is eomposed of ten eups and pairs, then ten equivalents of zinc must be eonsumed to decompose one equivalent of water — thirty where there are thirty cups, and so on. It would seem, then, to be much better to employ only one or two cups and pairs, sinee to produce the same effects, where no great resistance is to be overcome, we can save some ten to thirty parts of zinc. But we find that the decomposition is less free, and also the electrolite *requires* a current possessing a eertain degree of intensity, or, what amounts to the same thing, having an electro-motive *force* of a certain power, which ean best be given it by multiplying the number of eups. So, also, as regards great resistanees that are to be surmounted; M. De la Rive says, "When a current is ealled upon to traverse a long telegraph wire, it is necessary for it to be aecomplished to use a numerous suceession of eups, for if it were attempted to be produeed by only one or two cups and pairs, no matter how great their size and power, it would not have sufficient *intensity* to overeome the resistanee of the long wire."

We must also be reminded, that the *size* of surface of the galvanic pair or pairs is able to influence *only the quantity* of chemical action exerted in a given time; but that it can in no way modify the electro-motive *force* of the pair or pairs, nor will there be the eapability of the produced electricity for surmounting a given resistanec; for where this resistance exceeds a eertain bound, itself limits the quantity of efficacious ehemical, or catalytieal action, by the very defieient quantity of electricity that can be transmitted in a given time, and hence renders useless the increased surfaee of the plates beyond a eertain size, which is in relation to that of the resistance and kind of work to be done. The *quantity* of the eurrent is in proportion to the *size* of the pair; the *intensity* of a given current is in proportion to the *number* of pairs.

On the whole, then, we see that the law of electro-chemieal aetion, as far as it eoneerns the eleetrolysis placed in the given

circuit, exterior to the series of pairs, i. e., placed between the poles, is a *general law*, and applies therefore equally well to what takes place in the interior of the battery, as through the route of the conductors, and the body embraced between the poles. The galvanic *circuit* of a series, when closed, is indeed but a circle composed in parts and by bits of conductors, united end to end in the series of the battery through which the current circulates, in a manner perfectly uniform and identical. In this there is brought about a change, by a succession of polarizations and recompositions of the contrary electricities of the consecutive molecules, in such a way that if the current encounters *resistance* heat is evolved; if the molecules are compound, and the current is persistent, then there is chemical decomposition. All these effects are capable of being equal in all parts of the same circuit or circle, (for such it is,) including the contents of the cups themselves, on the one side, and no less so the matter included between the electrodes that is to be operated upon, on the other.

It is then understood that there is a marked difference between the quantity of electricity *produced*, and the quantity that actually *travels* the circuit, or, in other words, that penetrates and passes through the object of work that is between the poles. This is always more or less retarded, or facilitated, aside from the power or kind of battery, *according to the resistance* or poor conducting property *of the given object* that is acted upon. The result is necessarily different. There cannot be a current, as we have shown, without some degree of both quantity and intensity; but we now refer to these two relative properties. A single pair of almost any battery gives a quantity current, i. e., more of the character of *quantity* than of *intensity*. The former has the property for chemical decomposition, the latter for overcoming the resistance of an indifferent or bad conductor. Generally, we can increase the quantity by the larger extent of metal surface in the one battery cup; also by the kind of metals that constitute the pair, or by the increase of acids or salts in the liquid of the battery; in a word, by extensive and rapid oxidation or chemical action in the liquids or metals in a given time. But the *intensity* is increased, as we

have shown, by the increase of number in the pairs that compose the compound battery, but without an increase of size.

We conclude, then, that a galvanic current is great in *quantity*, and capable for chemical action, if produced by a single pair or more, much in proportion to the size and action of the pair if connected with a thick wire. The density, tension, and intensity of the current for passing over and through poor conductors will be much in proportion to the number of the series, and the smaller size of the wire connections and conductors. The efficiency of every battery depends upon good contacts. This is mentioned *particularly*, because the greatest and most frequent failures, partial failures, or differences of results, arise from this want of exact care.

There is another method for increasing the electro-motive force of even a small galvanic current of a single pair, as well as some modified *kind of intensity;* but this must be reserved for the next chapter.

Derived currents, spoken of by authors, are those that are obtained by a sort of *by-path*, namely, when the conductor of a closed circuit is conveying a galvanic current, this is termed the *primary current.* If, now, we add a short and nearly parallel conductor by making contact at its metallic ends, on the route of the primitive wire, a portion of the current will pass along the second wire, provided it is not much longer nor smaller, nor otherwise a poorer conductor, than the primary wire. And this is termed a *derived current.* The author, however, finds no use for such in therapeutics.

Electric Heat.

Heat can be produced by an obstructed or retarded current of electricity, as, for instance, where a large quantity current is led by a wire too small to convey it all freely, or through a poor conductor, as *platinum.* It may be evolved by the disruptive discharge between the two poles of a galvanic battery, where disintegration is effected, and the particles of one pole pass over to the other pole, with the evolution of *intense heat* and light.

If we but coil a fine bit of platinum wire into a small spiral, it may be heated, even *instantly*, to a white heat, by making contact with a galvanic battery of large-sized cups, of quick action, and few in number. Thus it can serve the most perfect office of a *cautery* that is known in surgery. For this purpose, as we have elsewhere explained, it takes some half dozen half-gallon jars of a Bunsen or Grove's battery.

It must be borne in mind that when using a compound galvanic battery of high series for remedial purposes, that the law of this current is *heat*, in proportion to the power of the current and the obstacle opposed. This capability of such a current is aroused, then, not only by a small or poor conducting wire, but also by passing through a portion of the human body, as in ordinary treatments. Therefore the operator must know that if the electrodes are retained for some time on the same spot, while a large current is flowing, there will be danger of producing a slough, simply from cooking the flesh by electric heat. Let the same current pass through a small quantity of water, as in a glass tube, and it is seen to be not only rapidly decomposed, but it also boils, and that instantly and furiously. But there need be no kind of danger of this accident occurring, except from sheer ignorance or carelessness.

Magnetism versus *Electricity.*—M. Becquerel contends that all bodies are more or less magnetic. The action of the magnet, it is known, was for a long time regarded as a special action exercised only upon certain bodies. Now, it is acknowledged to be all but universal, and perhaps quite so; for most bodies are found to be susceptible of experiencing its influence, although not endowed with magnetic properties. The action of the magnet is identical with the action exercised by closed electric currents, *exterior* to the circuit which they are traversing. This *law* is now admitted by all, for the identity rests at once upon experimental and mathematical proofs. It is also proved, says De la Rive, by the fact that these two species of action — i. e., certain extra-polar electric working and magnetic action — may in all cases be substituted for each other to produce, in varied degrees, the same effects under the same circumstances.

We find, also, the *law* that the characteristic properties of magnetic bodies are, volume for volume, those that contain the greatest number of chemical atoms; while dia-magnetic bodies are those that contain the least. Yet dia-magnetism is not a magnetism simply *relatively* more feeble. Both these classes of bodies are influenced only so long as there is a body which determines the manifestation; and that in proportion to the square of the intensity of the magnet or of the current, and not to the simple fact of intensity. This shows that these bodies are not passive, but enter somewhat into the production of the given result.

Induction Currents.

For a long time philosophers were impressed with the analogy there seemed to exist between electric and magnetic phenomena. There were manifested two magnetisms — the north and the south poles; as there were two electricities, plus and minus, or positive and negative. Indeed, very many of the phenomena of electricity in motion, are closely related to magnetism. The attractions and repulsions manifested between the two magnetisms, as between the two electricities, are according to similar laws.

In 1819 Professor Oersted, a Danish philosopher of Copenhagen, made the first scientific demonstration of the action of electricity upon a magnet. As Dr. Benjamin Franklin had demonstrated the identity of the lightning of the clouds with the spark of the friction machine, — which, indeed, had long been suspected and as much doubted, — so here was actually proved that which had been so long suspected and sought for by some, (while doubted and scouted by others,) but not where, and in the way, it had been thought to exist. The finding of M. Oersted was, that electricity acts upon a magnet, and that a magnet, in its turn, acts upon electricity; but *only* when the electricity is in motion.

The following is his fundamental experiment: When the poles of a galvanic battery are closed, so as to make a continuous conductor, and if this wire, while the current is traversing

it, is placed either above or below a magnetic needle which is freely suspended and parallel to its direction, the needle is immediately deviated, and all the more considerable as the galvanic current is more powerful. It tends to place itself transverse and perpendicular to the conductor wire of the battery — a position it nearly attains, provided it is near, and the battery current is sufficiently strong. In fact, the extent of the deviation of the needle is directly proportional to the power of the battery, and inversely proportional to the distance between the needle and the wire. But if it is a common magnetic needle, it will not be deflected so far as to assume a position exactly at right angles with the conducting wire, on account of the influence of the earth, which still acts upon the needle, and tends to draw it back to its natural magnetic meridian. Therefore it will come to rest in a place between the two forces, according to the predominance of the one or the other. The direction in which the deviation takes place depends upon two circumstances: the first is, the *position* of the conducting wire of the battery in relation to the magnetic needle, as it may be above or under it, or it may pass it perpendicularly with an up-running or down-running current; the second condition is, the *direction* of the current.

Ampère drew the attention of natural philosophers to the fact that the earth's magnetism prevents the magnetized needle from entirely obeying the influence of the electric current. To obviate this he proposed the *astatic needle*. He first, or M. Nobili, constructed this by placing a second needle above, parallel with, and near to, say within a half inch of, the traversing magnetic needle. The upper needle, being made fast on the same centre shaft with the first, moves on the same pivot; but its polarity is *reversed* as to the other, so as to neutralize its directive tendency in respect to the earth, and so that it shall remain at rest in any position. But the two needles cannot be *perfectly* alike in all respects, and possessed of absolutely the same quantity of magnetic

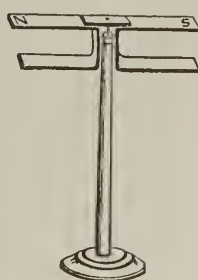


Fig. 15. Astatic Needle.

power, and therefore the globe will always have some degree of effect upon the static needle. Yet it is certainly proved that the electric current does, more promptly and completely, control a needle so prepared as to be *double* and reversed than the *single* magnetized needle.

If the conducting wire of the galvanic current is placed horizontally below the needle so as to run north, the north pole of the needle is instantly deviated eastward. If the electric current is now reversed so as to run southward, the north pole of the needle flies to the west. But if now the conducting wire is raised above the needle, and still horizontal, the deviations of the needle always occur in the contrary direction.

While M. Ampère took up M. Oersted's discovery to generalize and extend it, M. Arago was looking into this matter, and soon showed that an electric current not only acts upon a magnetized needle, but that it also acts upon all magnetizable bodies, even when they are not magnetized. Having coiled a small, soft iron wire, he found that when this wire was being traversed by a strong electric current, it acquired the property of attracting and retaining around it a certain quantity of iron filings, much like a cylindrical envelope, but that the instant the current ceased to pass the filings fell off; but as soon as the current run again, the wire took them up again.

M. Arago further showed that the powerful charge of a Leyden jar even, may magnetize a steel needle, if placed in the interior of a helix made of metal wire through which this discharge is made to pass. Sir H. Davy soon afterwards discovered that we can magnetize common sewing needles by merely rubbing them back and forth transversely over a rectilinear wire *while* it is being traversed by the electric current of a battery. These experiments prove that the electric current impresses upon battery conductors, that are thus traversed, properties perfectly like those of magnets, not only those of magnetic bodies: but in fact it actually magnetizes those thus traversed.

M. Ampère found, besides, that a galvanic current not only acts upon a magnet, but that it also exercises an action upon another contiguous electric current, which may be stated thus:

If two portions of straight, movable wires have constant galvanic currents coursing through them, they are then mutually *attractive* and *attracted*, while the current is still moving in the same direction; but if one of them is reversed, so that they run in contrary directions, then they are *repelling* and *repelled;* and this is not instantaneous, as with static electricity, but is continuous as long as the current continues to traverse the conductors. Thus the ascertained action of an electric current upon a magnetized needle had furnished the means in every respect for determining the existence, and for appreciating the force, of any sort of electric current. Immediately M. Schweigger, a German philosopher, applied these principles to the construction of the first galvanometer multiplier, which was employed by M. Nobili in his wonderful electro-physiological researches. M. Dubois-Reymond then constructed on this same principle a galvanometer of the utmost sensitiveness, and as remarkable for its accuracy, by employing more than 24,000 elliptical convolutions of insulated fine wire, by which he was enabled to detect the presence of electric currents even in almost all the tissues of the living animal body; and by this superior aid he arrived at his fundamental and special laws in electro-physiology.

Very soon after Oersted's discovery, Arago demonstrated that if a copper wire that is well covered with silk thread and varnish be rolled into the form of a helix around a bar of soft iron, and an electric current is then caused to pass through the wire so coiled and situated, *the soft iron becomes a powerful magnet*, and remains so as long as the current runs. He showed that it is with the greatest rapidity that soft iron is magnetized and demagnetized by the electric current. Such temporary magnets are termed *electro*-magnets, in order to distinguish them from permanent magnets of steel. Thus on, he showed that the electric current imparted a magnetic property to pieces of soft iron *temporarily*, to steel *permanently*, also to other bodies that did not possess it previously.

The term "*electricity of induction*" strictly means the development of electricity by the influence of other electricity in

proximity, or else by means of magnetism. That developed by the influence of the former is called electro-static or electro-dynamic induction, and also *electro-magnetism;* that of the latter is termed magneto-electric induction or *magneto-electricity*. When two *helices* (which are, indeed, but coils or bobbins of wire in which galvanic currents are then flowing in the same direction) are placed end to end, they attract each other; but if one of them is reversed, so as to give opposite currents, repulsion is manifested. So, according to Ampère's theory, when two permanent steel magnets are placed end to end, there is attraction or repulsion on the same principle.

If we take a Smee's battery, or a good sized and active sulphate of copper battery, and connect the poles by a *short* copper wire, no spark is usually perceived when the connection is formed or broken, but, if any, never at contact, and only very faint when opened. But if this connection wire is replaced by one that is fifty or a hundred feet long, the spark appears much brighter and more certain; but if we *coil* this wire as on a spool, then the spark is still more vivid and more uniform. The most advantageous length of wire coil for producing the greatest spark depends upon the diameter and quality of the wire, and also upon the quantity and intensity of the battery. If a battery of higher intensity is employed, such as Grove's, then the wire may be much further increased; but the greater the *quantity* of the electric current, the *shorter* or *larger* must be this wire in order to transmit the whole of the current, and to obtain the greatest effect or the brightest spark. By means of a wire some hundreds of feet in length, a slight shock may be felt from a single pair at the moment of opening the circuit, if its poles are arranged as moist electrodes, and are held in the hands. By testing it through the tongue, this intensity increases until the wire is some six or seven hundred feet long: by using a number of pairs, or even a smaller size, a greater length of wire in helix can be employed for shock or spark with greater effect. The maximum effects of a single small battery are, of course, less than those of a large one, and if the requisite length of wire for the given battery current is exceeded, the effects are diminished.

In 1831, Professor Henry, one of our American philosophers, was the first to discover this peculiar action of a long conductor when extended, and also, when *coiled into a helix*, as so modifying or *increasing* the current of a single galvanic pair *at the moment when it ceases to flow.* He was the first to employ coils of *metallic ribbon* for obtaining sparks and shocks from a single galvanic pair. By this means the brilliancy and power of the spark are very greatly increased whenever the circuit is broken.

Thus far had this branch of science advanced when in the same year Professor Faraday, of England, discovered that an *electric current*, as well as a *magnet*, *is able by induction to develop electric currents* in conducting wires. This he proved by placing on an insulating plane two parallel conducting wires very near to each other, but without touching. The two ends of one of these wires are connected with the poles of a galvanic battery, so that it in fact becomes the connecting wire between the two poles of that battery. The two ends of the other wire are connected with the extremities of a sensitive galvanometer, simply to judge of the electric movement in this wire, if any, by the deviations of the needle of the instrument. At the moment the battery current commenced to flow through the first wire, the needle of the instrument is seen to deviate at first, then to quiver and oscillate, and finally to come back to an equilibrium, which remains at zero, just as it was before the current was let on the first wire; and thus it remains undisturbed as long as the current of the battery continues to traverse the neighboring wire; but the instant the current is interrupted in the first wire, the needle suffers another deflection, and this in a contrary direction to that which occurred at the closure of the current. Thus he proved that the galvanic current which courses through the one wire, determines an instantaneous but opposite current in the other wire *at the moment when it begins to flow, and another equally instantaneous reverse current at the moment when it ceases.*

Dr. Faraday was led to suppose, from the manifest analogy existing between the properties of *magnets* and those of electro-dynamic *coils* or cylinders, that the same results would be obtained

by introducing into the interior of the hollow helix a magnet instead of the electro-dynamic coil; and this he demonstrated to be so, and that even in a much stronger degree. In fact, the electric current that traverses one of the helices or coils of the machine at the moment when it is established, not only de-

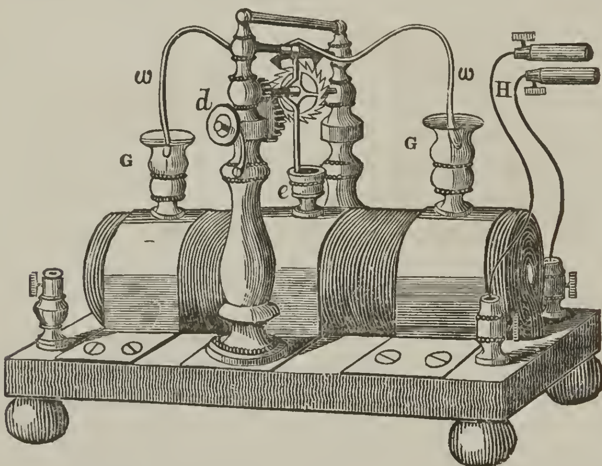


Fig. 16. An Electro-Magnetic Double Helix, with Clock-work for interrupting the Primary or Battery Current.

termines a current of electro-dynamic induction in the other coil of the helix, but at the same time, if there is placed a soft iron within the helix, it magnetizes it; and for this same reason also determines in the second coil a magneto-electric current *in the same direction, and much more powerful.* So, when the current *ceases* to pass, the soft iron being instantly demagnetized, there is developed a second induced current *from the magnet*, which is now also added to that which results from the direct effect on the second wire in the helix — all proceeding from the inducing current that is flowing from the battery through the first wire in the helix.

The first physician who employed *induction currents* for medical purposes was Dr. Neef, of Frankfort-on-the-Main. He first *invented* the automatic vibrating spring for interrupting the current, which indeed opened a new *era* in the therapeutical uses of electricity.

Electro-magnetic currents, as they have been more generally called, are usually obtained from a helix machine, in connection with a single galvanic pair, (which latter is of itself a battery;) but, taken together, this is known in our country as the *Electro-magnetic Machine*. The *kind* of electricity thus obtained could

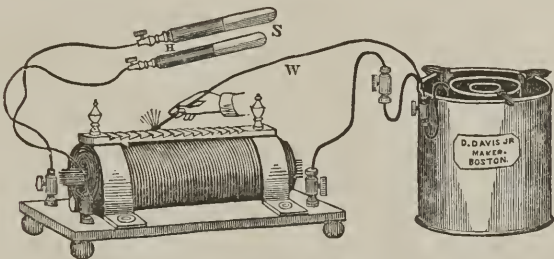


Fig. 17. Electro-magnetic Helix and Battery, with a Rasp for breaking the Current by hand.

be more strictly termed "galvano-magneto-electric currents of induction," because induced by both these sources combined, by the arrangement of one and the same apparatus. There are also other forms of induction currents that are called by other compound names. The author proposes, for the sake of conciseness and uniformity, to designate the peculiar kind of electricity obtained by any and all sorts of induction apparatus, whether from battery or permanent steel magnets, in connection with *medical purposes*, as *Faradaic electricity*, *Faradaic currents*, and so on. True, the initiatory steps that led on to this grand discovery had already been taken by Oersted, Ampère, Arago, and by Henry; yet to the illustrious English philosopher, Dr. Faraday, are we indebted most of all for this magnificent result. Besides, it is well known that Dr. Duchenne, of France, one of the most distinguished medical electricians of the age, has already designated, in his elaborate work, the "localization of induction currents to a single muscle" as "*Faradization*." Let that kind of *current*, then, in this relation, and the medical use of these currents, henceforth take his name.

The term *Faradaic electricity*, wherever it may recur in this work, is simply synonymous with the terms "induction currents," "electro-magnetism," or "magneto-electricity," and

stands in contradistinction to *Galvanic electricity*, for this latter term I confine strictly to primary battery currents.

The Electro-magnetic Machine gives us one of the most important forms of induction currents with which we have to do in all electro-therapeutics. Under this head, then, we must consider the construction and action of such apparatus, which are important, inasmuch as they have been, and still are, the more frequently resorted to for medical purposes. But these machines are found distributed already in great numbers through the various ranks of the medical profession in cities, towns, and counties over our continent, and also in very many private families, but which are constructed in a great variety of ways, or rather *forms*, and therefore require particular investigation; for it seems but reasonable that a medical man should well understand the instrument with which he proposes to operate.

To be the better understood, we will set out with the primary law of physics, namely, that we can only derive force from some prior change of matter, which change ultimately resolves itself into some new form. If we find we have a certain amount of action in a *single* galvanic battery, it is given us as the effect of relative quantity. When the action takes place in a *series* of elements, i. e., in more than one pair, then, in proportion to the number used, do we get the relative effects of intensity. Moreover all the kinds of electro-magnetic machines yield us a current of peculiar *intensity*, although from a single galvanic pair whose simple characteristic is *quantity*. This excellent result is obtained by the power electricity possesses when passing through a parallel and approximating wire, particularly when these wires are wound into coils of given lengths; and still more is the greatness of this result enhanced by the magnetic power that is also developed and exercised simultaneously in the same direction.

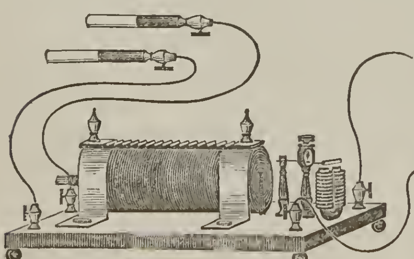


Fig. 18. Electro-magnetic Helix, with Vibrating Electrotome, but without its Battery.

The coil or helix of all these machines, that are useful, is made pretty much *on the same principle.* A stout copper wire is well covered with cotton thread and varnish, for perfect insulation; and then some ten to fifteen yards of this is first wound into a coil, (which forms the inside of the helix of every such machine,) so as to allow the two ends of this coarse wire coil, which is but a part of the helix, to connect with the galvanic battery. This is termed the *inducing wire*, and the current of the battery when passing through this inner and stouter wire is designated the *inducing current.* Indeed, this current does *induce* the additional power from *two sources* — the one from a bundle of soft iron wires or a piece of soft iron that is placed within the central cylindrical cavity in the helix, and the other power from the outer and second coil of the helix, that will soon be described. But to understand as we go. If, now, into the interior of this primary coil of wire there is inserted the piece of soft iron or the bundle of wires while the current flows through the coil, the wire or iron is magnetized by the power of the current that is only passing from the battery through the helix and back to the battery. This is proved by the visible effects on a common magnetic needle placed under the wire, but very close to it; or it is seen the better by a galvanometer, so arranged that the current passes through this instrument, when it is found to be very decidedly increased, because there is added to the primary current of the battery *the induced current from magnetic induction.*

To finish the helix as it is, or *should be*, there is wound on or over the bobbin of coarse *copper* wire, that we have just been experimenting with, a second coil of fine copper wire of good quality, that is also well covered with silk or cotton thread and varnish, for perfect insulation: of this there should be at least five hundred to fifteen hundred feet, closely laid in the same direction over the coarse inducing wire. When thus completed, the two ends of the primary or coarse inducing wire lead to, and connect with, the battery. The two ends of the outer secondary fine induction wire lead to binding screws, with which the electrodes and conductors can be adjusted so as to lead to the patient.

It has already been shown that when contact is made with the battery, the current which passes through the inner primary coarse wire determines in the second or outer longer and finer wire an instantaneous current *at the moment* when it *begins* to circulate, and another equally instantaneous current *at the moment* when it *ceases* to pass. Now, here is the peculiarity of this current from *electric induction;* i. e., it is thus always instantaneous, and that at the instant the inducing current *starts*, and again when it *stops.* The same is true of the currents of *magnetic induction.* But, fortunately, the magnetic current *can* act not only instantaneously and simultaneously, but also in the same direction with the other bits of currents; for these latter are not produced whilst the soft iron remains a magnet, but rather only when it gains and loses its magnetism. The demagnetization of the soft iron within the helix machine, therefore, must have the same effect as breaking the current of the battery in the production of an equally instantaneous current. It is clearly understood, then, that the current of the battery which circulates in the coarse wire of the helix never arrives at the patient. It is only the *induced* currents (from the two sources, namely, from the within magnetized soft iron, and the without long fine coil of the helix that is rendered electric *simultaneously* by the mutual action of the battery and the magnet) that are felt at the electrodes. The galvanometer indicates exactly, not only the existence of such currents as being only and always instantaneous, but also their *direction;* for if we compare the direction of the different currents, we find that the induced current — i. e., the one in the fine long wire that leads to the electrodes on *making* the circuit — is *contrary* to that of the current of the battery; while the direction of the one on *breaking* the circuit is in the *same* direction with that of the battery. We therefore find the *law*, *that these kinds of currents are but shocks*, *of only instantaneous duration*, *and that the direction of each alternate shock or current is invariably and necessarily in the contrary direction.*

To render such an arrangement available as a kind of *current*, there must be some contrivance for breaking and making

the original or inducing current of the battery with the greatest possible rapidity and uniformity; and this is most beautifully accomplished in the best of these machines by the "*trembler*" of Dr. Neef. This is done by electro-magnetic power acting automatically on a magnet of soft iron, about which are made several coils of the large wire that forms the inner coil of the helix and connects with the battery. There is placed over the arms of this miniature magnet a silver spring that is faced and loaded like a hammer with a small bit of soft iron. This spring vibrates, with a mere hum from rapidity between the tips of the magnet and the end of an adjustable screw at its back, which is also tipped, but with a point of platinum; and this strikes against a pin-head button of platinum attached to the silver spring. And here is the most delicate point in the whole apparatus. These platinum points *should be riveted* to their place, *but never soldered.* The solder will become decomposed by the electric spark that plays there, and after a while the machine appears to be uncertain, or even worthless, although perhaps a good machine in every other respect. The author must say he has seen not a few of such; and not only so, but he has often found the apparently good-sized helix stuffed with something, besides a thousand feet of insulated *copper* wire!

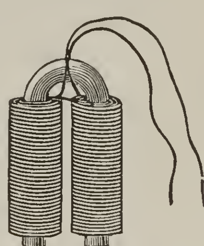


Fig. 19.
Electro-Magnet.

But to return. We have said that the original current of the battery is interrupted by the magnetic force of attraction and repulsion acting upon the silver spring, which is interposed so as to separate, and join the contact or continuity of the battery wire. The battery current renders the little soft iron a magnet, and this attracts the spring-hammer, and that demagnetizes the little magnet which allows the spring to fly back again; and thus is the current made and broken more rapidly and uniformly by electro-magnetic action than can be possibly done by any other mechanical arrangement. I should also mention, that the *face* of the iron on the spring should be kept clean and bright, as well

as the ends of the arms of the little magnet, for either grease or rust will stop its action. The *contacts* must all be carefully attended to. Much power is often lost by this neglect, besides the inconvenience of uncertain action, or no action at all.

Go where we will, as I have said, we find a great variety of these electro-magnetic machines. Nevertheless, they pos-

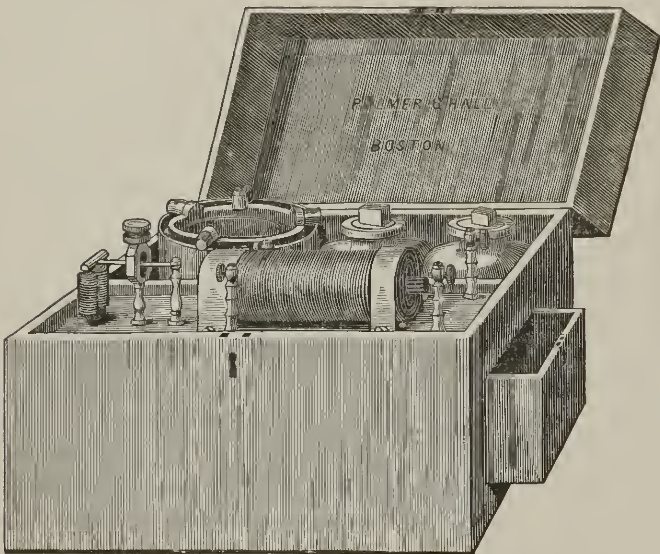


Fig. 20. Electro-Magnetic Portable Machine, complete in its Box.

sess in the main generally the same principle, and about the same internal arrangement or property for obtaining in a more or less degree an *intermitting and alternating current of intensity*, simply from a single galvanic battery of great relative quantity.

The intensity of these induction currents from a given machine depends, in the first place, upon the intensity of the battery action. If this is any way feeble, it will not develop a powerful magnetism; therefore the extra current from this source, as well as the current induced in the second or outer wire will be of low tension. The current can be made more

heating and chemical by using a large and active battery with strong solution. Of course, it can be regulated or reversed in this respect, even to the lowest degree, by lifting the metal pair partly out of the fluid, or by diluting the fluid, or both. The intensity of the current, as regards tension, can be graduated to the greatest nicety by adjusting the soft iron or the bundle of wires that can be more or less pulled out of the end of the helix, which reduces the current, while pushing them in increases the current. So great is this range of difference that it is absolutely necessary to graduate the current in this way, invariably *before* applying the moist electrodes to the patient.

Another important point is to have the machine attached to the battery *invariably but one way;* and it is better to have the strongest pole always come to the right hand as we face the machine. We then can keep in view the whole, for this is the negative electrode, and the point where the current always leaves the patient. Of course, the other must be the positive pole, and where the current always enters the body or limb of the patient. By thus accustoming one's self to operate only in one way, it is more easy to keep the whole story of "current direction" clear, while the mind is more intent on the anatomical and physiological phenomena of the case. It is easy to determine which is the strongest, and hence negative electrode, by simply pressing the moist wash-leather or sponge of each electrode into the palm of each hand, and particularly if so as to cover the inner edge of the adductors of the thumbs, which will respond by contraction most strongly to the negative electrode. The current should be strong, and the moist electrodes should be exchanged from hand to hand, back and forth, several times, until this is fairly demonstrated to our satisfaction. But we must always bear in mind that there is *no absolutely* positive or negative pole to any of these electro-magnetic apparatus. Only the more slight decompositions can be effected by any of these medical apparatus ; but this is shown at both poles simultaneously, and simply more at one than at the other.

Magneto-Electricity.

Magneto-electricity is a term used to designate certain induction currents from other induction currents called *electro-magnetic*,—these latter being produced by the electro-magnetic machine, while the former are produced, on the contrary, by permanent magnets which are called magneto-electric machines. This, too, was the result of Dr. Faraday's profound researches. He found that if the poles of an ordinary horseshoe magnet be *approached* by one of the ends of a copper wire, that is thoroughly insulated and wound like a helix around a wooden spool, then the needle of the galvanometer which is in the circuit is immediately deflected, but that the needle soon comes again to rest. This, he observed, was repeated also when the end of the wire was *removed* from the pole of the magnet, and that in the opposite direction; and then again the needle soon came to rest. This indicated that an instantaneous current of a given direction is produced when the wire of the helix *approaches* the pole of the magnet,—and that this is repeated, but in the opposite direction, when the wire is *receding* from the magnet. For producing a succession of shocks, so as to make up a current, the magnet, or else the wire, must be regularly approached and withdrawn in quick succession. To bring this about in the most effective and practical manner, there is hung upon a shaft a soft iron *armature*, that is wound on both arms with a long coil of copper wire for induction, and this is set in revolving motion near the poles of a large and fixed permanent magnet by means of crank, wheels and gearing. This is kept in lively motion by some person turning the wheel, the which turns the armatures some eight times around to its once, and the armatures thus passing the poles of the magnet twice to every turn of it, makes some sixteen shocks to every turn of the crank. Every time the armature coils approach and pass the poles of the great compound permanent magnet, the soft iron armature is magnetized and demagnetized, and thus two momentary currents of electricity are educed,—the one at the instant of approaching

and magnetizing, the other at the instant of passing off and demagnetizing.

The magneto-electric machine is heavy according to its power; but it is in a box, compact, dry, and neat. Its inten-

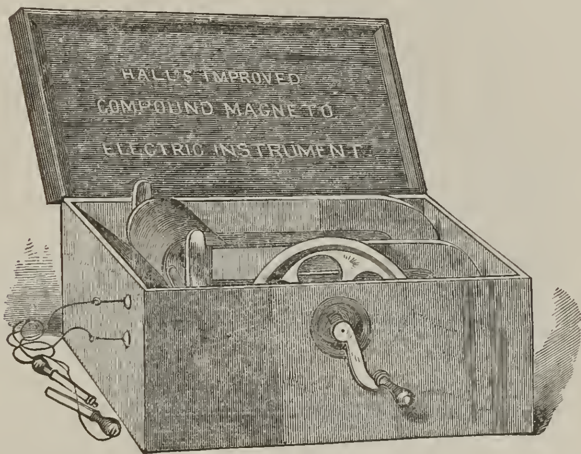


Fig. 21. Magneto-Electric Portable Machine complete in its Box.

sity depends, first, upon the power of the great magnet, whether single or compound; second, upon the size of the wire that is wound around the armature, and also upon the number of its convolutions; third, upon the exact nearness of the revolving armature to the tips of the poles or arms of the great magnet; fourth, and finally, upon the velocity and regularity with which the wheel is turned.

In this machine it is easy to arrange a spring cut-off on the large shaft of the armature so as to strike an alternate cog of brass and ivory, and thus to effectually intercept *one* set of the shocks that make up a one-way current, leaving the other to pass to the electrodes, as a current made up of fine shocks or bits of currents, but *all in one direction.* This can be demonstrated by showing decomposition of iodide of potassium or starch only at one pole. Thus we have not only an induction current with a nominal pole, but here are the positive and negative poles *truly so* in effect.

The most wonderful magneto-electric machine, of which we have heard, is the apparatus arranged by Mr. Henly, of England. In his machine there are arranged two banks of per-

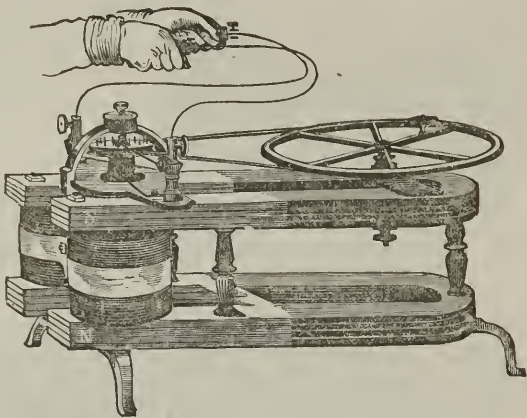


Fig. 22. Magneto-Electric Machine, showing its revolving Double Armature.

manent magnets, each of which is two feet and a half long, and five inches broad; each is made of extra steel, which was long and laboriously hammered. The induction coils on the two arms of the ponderous revolving soft iron armature contain some *six miles* of insulated copper wire, and all this is driven with great velocity and regularity by machinery and steam power. It is said that the electric power of this apparatus far exceeds that of Rhumkorff's coil; for the current obtained from the former is readily sufficient to kill a man or an ox instantly.

The physiological effects of magneto-electric currents are produced on making, as well as on breaking, the circuit; but the latter are stronger than the former, yet not to so great a degree as between the make and break in the battery circuit of the electro-magnetic currents. Therefore, when employing Faradaic currents for physiological and therapeutical purposes, we are allowed to take into the account merely the strongest current, i. e., those induced on opening the current of the battery in electro-magnetism, or on demagnetizing the armature in magneto-electricity.

If we want to avoid the incessant change in these currents, and to operate rather with a succession of currents *all guided in the same direction*, we must have recourse to the magneto-electric machine, as this has, or can have, an arrangement for that purpose; while the automatic action of the battery induction *will not allow* of any such provisional arrangement.

We observe, then, that *Galvanic* currents differ from *Faradaic* currents in the following respects: —

First. The former are continuous and in one direction; the latter are always in interruptions, and these in rapid alternate directions; but as the terminal shock is stronger than the initial shock, so, when taken together, they make a stronger current in that direction; and hence we *nominally* call one positive, and the other negative, although *in fact* and effect, to a degree, they are both alternately positive and negative, only one electrode is stronger than the other.

Second. When the decomposition of water is brought about by the galvanic current, the hydrogen appears invariably at the negative and the oxygen at the positive pole. But if we decompose water by Faradaic currents, this is not the case, as each pole is *alternately* serving first for the positive and then for the negative pole, in rapid alternations, so that both hydrogen and oxygen appear at both poles. If these induction currents succeed each other very rapidly, it may even happen that both gases appear simultaneously at either pole, and, both being in a nascent state, they combine again so rapidly to form water that the result is as if the water was apparently not at all decomposed by these induced currents.

Third. Another evidence that the Galvanic current and Faradaic current are not alike, is, by bringing a solution of the iodide of potassium and starch into the circuit of each; for then the blue color that indicates the liberation of iodine will shortly but moderately appear at *both* of the poles of Faradaic currents; while by the Galvanic current we notice the blue color quickly, and *only at the positive pole*.

ELECTRODES OR POLES FOR MEDICAL PURPOSES.

Fig. 23. Fig. 24. Fig. 25. Fig. 26. Fig. 27. Fig. 28.

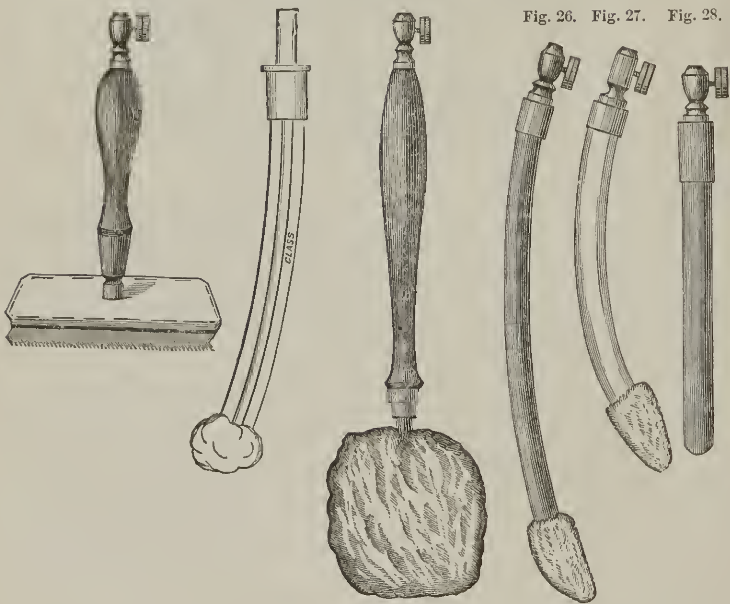


Fig. 23. Wire Brush Electrode for some local Faradization.
" 24. Sponge-tip Glass Electrode for Vagina.
" 25. Large and fine Sponge Electrode for general purposes.
" 26. Gutta-percha Flexible Electrode for Face, Mouth, and Fauces.
" 27. Gutta-percha and Sponge-tip Electrode for Uterus and Rectum.
" 28. Metallic Electrode, heavy silver plated, oval tip.

P. S. — All the above should be well insulated, neat, and durable.

Fig. 29. Fig. 30. Fig. 31. Fig. 32. Fig. 33. Fig. 34. Fig. 35. Fig. 36.

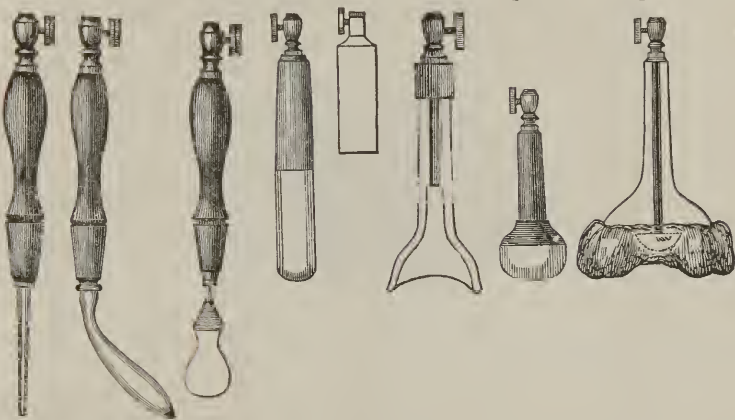
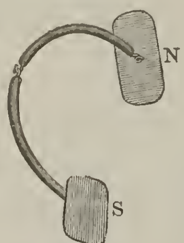


Fig. 29. Electrode for the Ear, and other delicate purposes.
" 30. Electrode for Throat and Fauces.
" 31. Electrode of Silver, for the Tongue.
" 32. Handle Electrode, half insulated.
" 33. Handle Electrode, and Metallic Hollow for Sponge.
" 34. Glass Electrode for the Eye.
" 35. Ball Electrode covered with Wash-leather. There are *three sizes* of these, for placing over nerve-trunks.
" 36. Large fine Sponge Electrode with Glass Handle.

P. S. — No Electrode should be used the second time without having been perfectly cleansed. This is done for the sponges, in the first place, by warm water and soap; then rinse and pass them through dilute *chloride of sodium*, or dilute muriatic acid, say one part of the chloride or acid to ten parts of water; then rinse them again, when they will be sweet as new.

A view of *Garratt's Portable Primary Battery*, for medical purposes, consisting of 1, 10, 25, 50, or 100 adjustable elements. (See page 114.)



A view of *Humboldt's Battery*, consisting of one primary element. (See page 113.)

A view of *Garratt's Sponge Electrode*, insulated with rubber, gutta percha, or glass, for medical purposes.

Fig. 44.

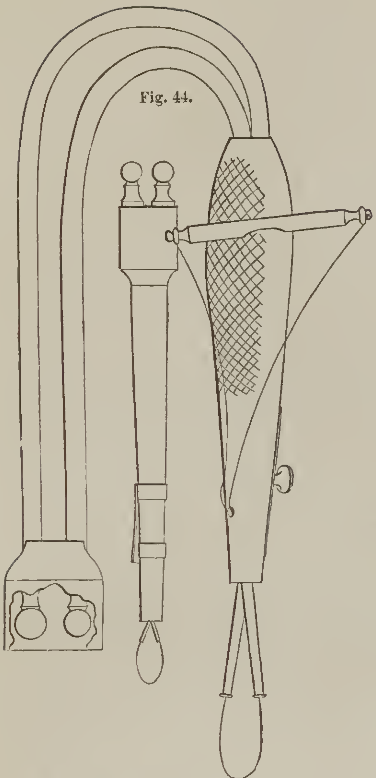


Fig. 45.

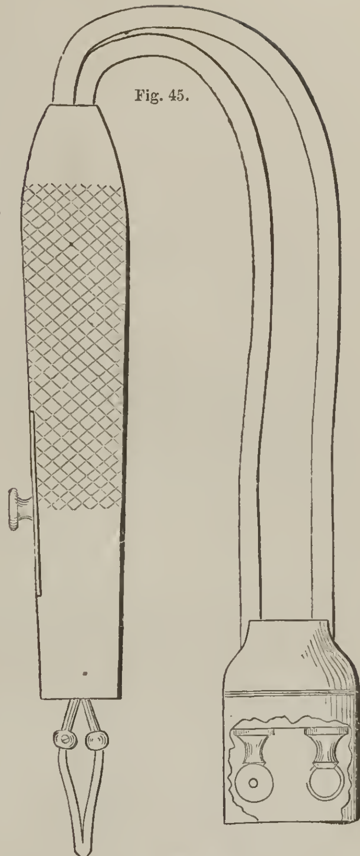


Fig. 46.

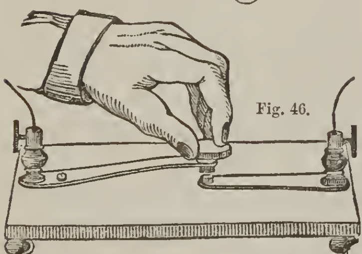


Fig. 47.

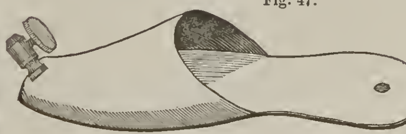


Fig. 44. Electrode Loop for Galvano-Cauterization.
" 45. Electrode Point for Galvano-Cauterization.
" 46. Foot-Board, or Current-Breaker, for Dentists.
" 47. Electrode Slipper.

P. S. — Every Electrode should be cleansed *immediately after being used*, and thus kept in scrupulous neatness and order.

CHAPTER IV.

ELECTRO-PHYSIOLOGY.

Electro-Biology.

THE researches of modern physiologists have clearly shown that all *organic beings* are resolved into ultimate cells, and that the functions of growth and nutrition are performed through these cells. Here, then, is the nucleus and sum total of life. But the great French physician, Bichat, says, "Life is the sum of those functions by which death is resisted." Life, in its widest signification, says Dr. Alfred Smee, is a term to designate the combined functions of assimilation, growth, nutrition, excretion, &c.; that these changes, occurring in the organization of man, constitute the vital phenomena of life; that these, together with the action of the senses, of thought, memory, reason, word, and deed, are consequently subject and obedient to physical laws; and that the functions of animal life are alike obedient to the fundamental law in physics, namely, that no force can possibly be generated without some corresponding equivalent change in matter. This is demonstrated in man, as we observe after action; for there is an increase of excretion, with greater desire for food and rest.

With regard to these ultimate cells of animal bodies, one of the most wonderful and extraordinary results which I have observed is, the action of electricity by induction, as obtained in the interrupted to-and-fro currents of electro-magnetism. But to study them in their nicest forms we often must have recourse to cases where they are found to exist in the simplest conditions. When the web of a frog's foot, for instance, is placed in the field of the microscope and this kind of current is directed through

the living animal, the circulation in the vessels of the foot tissues is seen to stop instantly, as if by magic. The current of venous blood which naturally flows from the capillaries towards the larger veins, as seen just before, not only stops, but also soon begins to retrograde slightly; while the current of arterial blood (just before observed as flowing in the smallest ramification of arteries *towards* the capillaries) is seen now to tend a little towards the capillaries, and even to be drawn into them, while the capillaries are all enlarged. The consequence is, they are engorged, as we also can see them under the skin by the naked eye. When the electric current is withdrawn, after it has been running for about a minute, the blood is seen to move on again, flowing in its natural order, both in the veins and in the arteries, only more rapidly than before the trial, and the engorgement soon vanishes. But on applying the electric current again, the same phenomenon is reproduced. The action of the current is as marked upon the lymph corpuscule as on the common blood corpuscules; and this we hold to be a very significant fact, because they move flowing rather along the *side* of the vessels, and are therefore less acted upon by the *vis a tergo* of the heart's action.

But we may be asked, How do Galvanic or Faradaic currents act upon the living human organism? Or rather, What are the first radical effects? Dr. Alfred Smee thinks the surface pole of the *peripheral battery*, in his scheme of nervo-electric battery of animal life, is excited to increased action, inasmuch as when two needles are placed respectively the one in the skin and fascia, while the other is plunged deep into the substance of the live muscle by the closure of a conductor between them, there is indicated by the galvanometer a decided *native current*. But this does not answer the question. If it were put to me I would say, In part it is known, but in part we do not know. The every where present *vitality*, unknown and yet seen, in all parts of living bodies, is the *mainspring* of life; but as no one knows what that is, *who will attempt to explain it?*

M. Matteucci has proved that there exists in the muscles a material which is highly nitrogenous and *acid*, while in the blood

the nitrogenous materials are *alkaline*, and the nerves are *neutral.* The voltaic arrangement of the human body consists in animal membranes and fluids, with nerve-fibres for connecting; and the result is, the most exquisite self-sustaining battery arrangement, that yields a kind of constant voltaic electricity, modified by vitality. It was Philippo Pacini, an Italian physician, who, in 1830, first described nerve-corpuscules, or appendages to the cutaneous nerves, as found particularly at the wrist, elbow, thigh, and intercostal spaces, and also in the solar and sacral plexuses. These *Pacinian corpuscules* were, possibly, noticed as early as 1741 by Lehmann, which he termed *papillæ nervosæ.* In each of these corpuscules there is a terminal nerve filament, and also an arterial radical. They doubtless have to do with the electro-nervous battery, as a whole; but what their office is, is not fairly known. (See pp. 222, 264.)

It is known, moreover, that minute cells are found throughout the gray matter of the brain, which may be supposed to be the active portion, and possibly the central poles, of the electro-nerve power. Here the requisites of arterial blood and of nerves are supplied in the greatest abundance, so that the brain is literally nothing but nerve fibres, blood vessels, or nerve tubes. In fact, the whole of the white layers — as, for instance, the *corpora striata* — are mainly nerve fibrils; while the gray portion is mostly supplied with blood, and that in a truly wonderful structure. The mechanism is here complex; yet is it still more and more beautiful and wonderful every step we take in understanding it as a means to an end, designed and built by the all-wise Architect as the *nicest* of his material works.

There are strong reasons for believing, says Alfred Smee, in his "Electro-Biology," that the brain is a double organ, and that the two impressions—when received on each side of the body or limbs — give but one idea to the mind. To preserve this doubleness of the apparatus — that is to say, to have the action in duplicate — each nerve fibre must be connected with a corresponding nerve fibre on the *opposite* side of the body. Thus two distinct systems of brain apparatus are formed, of which one is exactly the duplicate of the other; so that any action on

the one side is manifested on both sides alike. The mode of arrangement appears to vary in certain parts; for instance, as in vision, as a very peculiar contrivance is seen in the commissure of the optic nerve. Here the two inner portions of each probably divide: the one part continues in its course, while the other crosses over to its neighbor. In this way the sum total of the field of vision is represented on each side of the brain. To a degree, therefore, it must be true that the actions of the body have a definite source in the gray matter of the brain, as anatomy and pathology show. From these facts we should expect that a severing of the *pedunculi cerebelli* on the one side would determine a motion *towards the opposite* — a fact which actually occurs; "for of all the singular physiological effects which can be produced, there is none more remarkable or instructive than the continued whirling, revolving, or rolling motions of an animal *thus* injured," says a distinguished naturalist of the present day.

If, then, (as it seems plausible to suppose,) the peripheric nerves of all the body and limbs are one pole, while the brain is the other pole,—i. e. the former the positive and the other the negative pole of the electro-nerve circuit, — we can in some measure see why the actual transition from pleasure to pain can be so near and sudden. An impression can be made on any part of the body with more or less pleasure to a certain pitch; but beyond that point, pain immediately ensues, which, if sufficiently increased, can be followed with palsy: this, if increased still greater, can be followed with death.

If a very minute or delicately thin piece of metal be placed in a glass tube, and a large electric current be now passed through it by bringing it in the circuit of an active battery, the metal will then be likely to be instantly dissolved, and the circuit might not be readily completed by that route again. Dr. Smee says that what is true in this respect of such a pole is true also of liquid poles, and of intervening fluids. Where repair is constantly necessary, as it is in the brain, a very strong impression would more than equal the ordinary supply; and this action through that delicate combination and medium might thus be stopped.

The effect upon the brain in such a case appears to amount to more than exhaustion, as the delicate mass appears to be damaged permanently, and the action through that particular route does not readily, nor yet even always, again take place. It is on this ground, doubtless, that strong moral emotions sometimes instantly destroy life; for if each little sub-battery of ganglia, or of periphery, do affect the great central nerve battery, so that a very strong impression made on the brain could influence by *reflex action* every nerve of the body, then if this action is so great at any given time as to *quite* exhaust them, vitality is done, and life must *necessarily* be extinct. See p. 222.

It is not a little interesting, says Dr. Smee, in his *Sources of Physics*, to notice that *desire* in mental operations is similar in all respects to *tension* in the voltaïc battery. When the desire is gratified, it ceases for a time. This phenomenon is precisely similar to an exhausted battery in which an arrangement exists for replenishing the exciting fluid, as, in this case, after a time the battery would again become active and exhibit tension; and this is the same as desire ungratified. Hence he concludes, that man is perfectly free to act in any manner from external impressions; but after he has once received those impressions, they also wonderfully influence his future course. When the moral law is *profoundly* impressed on the brain battery, this will predominate, control, and rule each specific instance; but if feebly impressed, then each immediate impression is not controlled, but is controlling, and then the individual acts according to the more immediate pleasure or pain.

From these considerations man is taught that his *mental* functions proceed from the integrity of his brain organization. If it is incomplete, then the mental phenomena must be imperfect. A skull that is manifestly incompetent in size and proportion to contain the *usual* entire central electro-nerve battery indicates that the individual is deficient in mental power, *unless the contained brain is fine and high-toned.* True, we sometimes see perfectly-formed skulls, and those of *ample* size, with atonic or atrophied brains inside; and the result is a very small mental capacity, or even idiocy. Hence the author cordially concurs in

the deductions not only of Hugh Miller, from pre-Adamite nature, but also with Dr. Alfred Smee, upon this subject, i. e. *we know from the very organization of our bodies, that we are immortal;* that God *exists;* that there is virtue and vice, and eternity with its conditional rewards.

Man, in every age, climate, and continent, is compelled by his very *construction* and *nature* to believe *these first principles.* That which is infinite must not be limited; time must not be confounded with eternity, matter with space, the body with the soul, nor yet material actions from physical causes with God and his special providence. Thus are we taught the importance of religion, and, *a fortiori*, the absolute necessity that this should be pure, holy, and undefiled. Let the teachers of religion, and the teachers in all departments of science, *rest assured*, says Professor Phelps, of Andover, that they will approximate *inevitably*, although by opposite roads and methods, to the exact, self-same truths, which are for the very best well-being of the body as well as that of the soul. The former may influence man *from general principles* to control each specific act, while the latter, through the inflexibility of nature's laws, trace up each specific impression and action to a whole under general laws, *and these all, if they be true, must both essentially and minutely agree.*

The human species can have cognizance not only of single sentient impressions, and of combined sentient impressions, but we also derive a single idea from the sum total of all the impressions of each sense. This capacity is believed to belong to man alone, and is consequently a proof of mental power. Now, this is found most beautifully illustrated in those practical galvanic arrangements for obtaining a *single impression* from a multitude of separate actions. It is only necessary there to connect all the combined voltaic arrangements, so as to act as a single battery, which will then exhibit *action*, whether one, a part, or all the separate batteries are excited. It is, moreover, imperatively necessary to assume a mechanism in man, which shall collect the ultimate combinations of the respective senses into one whole, and this is inferred from voltaic laws, and is believed to

be found complete in the structure of the brain; for it is now manifest that almost every structure and arrangement here found may be nearly imitated by voltaic arrangements, combinations, and manifestations.

Muscular motion consists in a change in the arrangement and composition of the matter contained within the ultimate fibres, so that they become shorter, and consequently thicker and wider in diameter; and simply this is contraction, and this latter moves the limbs. Nerves are distributed to all the muscles; but this supply is in a very unequal degree. The termination of the larger muscle nerves appears often to abut on many muscle fibres, and also to be in *loops*, running likewise *transversely* to the general course of the muscle fibre. Each of these muscle fibres is completely enveloped by the minute blood vessels which run parallel with them. This admirable arrangement of the capillaries yields the abundant supply of bright arterial blood, so necessary for the manifestation of muscular motion; as contractions evidently ensue from changes taking place in the material in, of, and about the ultimate fibre by

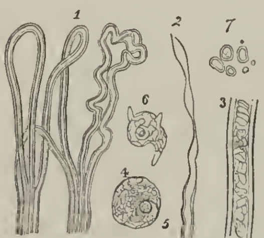


Fig. 48. A View of the Minute Structure of the terminations of all Nerve-Fibrils, both to the skin, in the muscle fibres, and in the brain substance.*

* 1. The mode of termination of nerve-fibrils in loops: three are seen to be simple; the fourth is convoluted. The latter is usually found where an exalted degree of *sensation* exists.

2. A nerve-fibril from the brain, showing a varicose appearance, which is possibly produced by traction or pressure.

3. A nerve-fibril highly magnified to show its structure — a tubular form containing the *neurine mass*, consisting of cells embedded in soft granular material, which appears to serve as a simple bond of connection between them. These cells, says Dr. Druitt, vary in size from one one-thousandth to one five-thousandth of an inch in diameter. They are of a reddish-gray color, and are composed of a capsule containing a granular pulp and a true nucleolated nucleus that is adherent to the inner surface of the investing capsule. The contents of the nucleus are similar to the contents of the parent cell.

4. A nerve-cell, highly magnified, showing its composition.

5. Shows its nucleus to contain a *nucleolus*.

6. A nerve-cell from which several *caudate* processes are given off. Nerve-cells are mostly globular, but some are oval.

7. Shows the *third* constituent of the medullary masses, mere granules, or still more minute cells; these, in the cerebral fibres, are in greatest numbers, of different sizes and often nucleated.

a nervo-voltaic process; and also, perhaps, by artificial galvanism. Dr. Smee says, considering the *vast power of muscular fibre* produced simply from the apparently small amount of voltaic force, it appears as if muscle is a kind of *minute compound voltaic battery* of membranous cells,—just such as, indeed, we make use of in electro-metallurgy for obtaining many equivalents of results from one equivalent of force. We find alternate minute blood vessels and ultimate sarcous fibre, every alternation of which might be interpreted as one voltaic cell.

It is become a current opinion among physiologists that a muscular contraction ensues from an *intermittent*, *natural* nervo-electric current. This is demonstrated on the leg of an animal by vivisection: if we cut all the muscles of the limb of one kind, as all the flexors, for instance, or, leaving them entire, and cutting across all the extensors, then, by applying the continuous steady current of galvanism, we obtain, and even maintain, a continuous contraction for flexion or extension; i. e., as long as the current flows. This *muscular action* is repeated as often as is the electric current.

M. Ampère lays down the *law* that each atom of matter possesses an electricity proper to itself; that this may be either positive or negative, and that in a state of equilibrium, for it is always surrounded by an atmosphere of electricity of a contrary nature to its own, which disguises the latter. But this may not be invariably true. M. Berzelius held that each atom has two electric poles, — one positive and the other negative, — which most beautifully illustrates and unravels indeed many chemical and electro-chemical phenomena. M. De la Rive admits that each molecule not only has two electric sides, but also a natural *polarity*.

Setting out, then, from this primitive law of the polarity of the atom, it is easy for us to deduce from it, according to the known laws of electricity, the manifestations of bodies under the action of closed electric currents. But we must observe that all philosophers agree in recognizing the difference between the *chemical atom* and the *physical molecule*; i. e., that the mole-

cule is only an agglomeration of a greater or less number of atoms.

When we take into consideration the general alterations occurring in the brain as well as in all the body, it by no means follows that exactly the same change in degree or kind occurs in both. This includes that vastly comprehensive subject of *waste and repair;* for, as says a philosopher, "we can no more obtain light without consuming oil, or its equivalent, or heat without the combustion of fuel, and that too with the product of soot and ashes, than we can obtain animal force without the creature receiving food and excreting the debris." Bright arterial blood must flow throughout the whole from pole to pole, i. e., from the centre to the surface corpuscules, and so to the stations of ganglia and to the brain. The electrolyte of both extremities of these nerve routes is liquid, and as healthy serum contains neutral salts, it is under all the better state for exactly such electrical purposes, *minus* vitality.

It is a *law* of the voltaic circuit that no polarity can occur unless there be some difference in the two poles, either in reference to their individual power of combining with oxygen, or from other circumstances that places them in different relations, such, at least, as variations in temperature, in extent of surface, in state of surface, or in their fluids having a different affinity for the given pole. Now, when we have a difference even in any *one* of these respects, then we as certainly have a voltaic circuit, determined *from* that pole which renders most capable for combining with oxygen.

In reference to the changes taking place between the elements of protien, which is largely contained in muscles, Liebig says, the elements of protien, starch, oxygen, and water undergo transformation together, and mutually affect each other. We obtain, as the product of this metamorphosis, urea, choleric acid, ammonia, and carbonic acid; and besides these, no other product whatever. We here have the chief constituents of animal secretions and excretions, viz., carbonic acid, as eliminated by the lungs, urea and ammonia by the kidneys, and choleic acid secreted and eliminated by the liver into the

duodenum, and from thence out of the body. Now, all these changes appertain to the peripheral nerve batteries, from whence comes our main source of physical power. Other transformations are also going on at the brain pole, particularly those in the gray substance, where phosphorus and red blood are *most profusely* provided; for certain it is that mental labor, or a nerve exhaustion from any cause, *always loads the urine richly with phosphates*. Now, this change of matter causes a continual waste, and demands a new supply; indeed, if not supplied or remedied, that individual will rapidly dilapidate. The changed matter, which has become the effete material, will *clog* the system, and interfere with the nervo-voltaic actions, or overtax the particular organs that continue to eliminate it. Organic disease will soon follow the functional derangement. This is sometimes a great perplexity to the physician; but what is difficult for us, Nature effects systematically and with the greatest perfection, particularly if we aid her.

We perceive that the blood absorbs the carbonic acid just as soon as formed within the capillaries, from the galvanic results, and now it is called *venous blood*, as it sets out with this its normal freight, washing it along to the lungs to be exhaled. Urea is also absorbed by the venous blood, and carried rather to the kidneys, while the choleic is cast off through the corpuscules of the liver. If the first important process be stopped but for five minutes, death is the result. If the second is stopped for five days, life may be extinguished. If the third be actually stopped still longer, shorter in some than in others, and that in proportion to the vicarious actions, life dies down inevitably to extinction. This proves that the animal battery for animal electricity must be kept clean; the batteries must be *recharged*, on and on, by taking suitable food and medicine, and we must as regularly and faithfully eliminate the resulting debris.

The actual bearing of these investigations, I need hardly state, in the way of both *general and special principles* in this department of medicine, is in the highest degree instructive. It shows that in whatever process or function of the human

body the blood is most essential, these, nothing less than true voltaic or animal electric actions and *life force*, must also have an influence. Furthermore, since it is self-evident that the circulation of the blood has thus to do, more or less, with every operation of the living body, I will only add that these experiments and considerations demonstrate the vast importance of employing artificial electricity, if possible, *as a co-worker with nature's similar actions in our organisms* as a rational, natural, and extensive remedial agent.

"*Hallerian Irritability*" *and Electro-physiological Experiments.*

Humboldt, in his Cosmos, has called astronomy the science of the universe without; but here, as a philosopher remarks, we are observing the no less suggestive and astonishing phenomenon through electro-physiology, viz., *the science of the universe within.* As we have already shown, the sum total of the entire apparatus of human life is but a due balance of forces acting and reacting as an elastic equilibrium which thus continues during health, but with an ever-varying and natural fluctuation, produced from impressions necessarily made from the world without, upon or through the peripheric nerve-pole, or else upon the inner nerve-pole from the same source, or else from ideas therein generated.

Dr. Francis Glisson appears to have been the first to use the word "*irritability*" in a physiological sense.* But he ascribed an irritability proper to all the tissues of the human organism, even to the fluids and bones; and thus "*motiva fibrarum facultas, nisi irritabilis foret, vel perpetuo quiesceret vel perpetuo idem ageret. Actionum igitur earum varietates et differentiæ earundem irritabilitatem clare demonstrant.*" But the great Haller was the first to declare the *vis musculosa insita;*† i. e., a property inherent in the muscular fibre that is capable of being excited to contraction, independent of any immediate instru-

* Tractatus de Ventriculo et Intestinis. Batavor, 1691, p. 168.

† Elementa Physiologiæ, vol. iv. lib. xi. Lusannæ, 1762.

mentality of a nerve whatever. This raised the question, "Are the motor nerves absolutely necessary to bring about muscular contractions and motions?" We must be reminded that Haller was the first to make the nice distinction between the *functions of motion* and the functions of *sensation*, while Sir Charles Bell, in later years, was the first to make the anatomical demonstration of a difference in the *organs* for producing motion and sensation; i. e., to show that there are *sentient nerves* and *motor nerves*. According to Haller, *irritability* and *sensibility* are properties totally unlike and independent of each other. He claimed, in short, that the *nerves* do not possess the slightest degree of irritability, since they are never put in motion themselves, whatever be the stimulus that is applied to them. He termed *irritable* the muscular fibre, and whatever of the human organism that contracts; i. e., that shortens from being touched by any foreign body. On the contrary, he termed *sensitive* the nervous fibril, and whatever of the human organism that on being touched by a foreign body, transmits to the mind the impression of contact, whether pleasurable or painful; and that sensibility is a property which ceases with life. That irritability, on the contrary, is to be observed for a certain time after life has become extinct. That if motion be brought about through the instrumentality of the nerves, *it is only by their conducting the orders of the will*, viz., volition to the muscles.

This creed of Haller, upon which the medical world has ever since been divided, was first opposed by Dr. Muzer, a distinguished German physician.* He first proved that there are nerves in all muscular organs, and maintained that the nerves are the only excitors of muscular motion. After the galvanic discovery, this of all questions was taken up afresh by both parties. (These items are introduced here because they have a direct bearing upon the subject; besides, we must be reminded that this question of *Hallerian irritability* is the "shading and light" of almost all the works given by the very distinguished names we are to consult.) One party, at the head of which was

* Erste Grunde einer Physiologie. Leipzig, 1771.

Galvani, Volta, and Valli, contended that muscular contractions were rendered most strong from the immediate *contact* of the metallic stimulus to the cut and raw surface of the muscle, without touching the nerve. But others, as Baron Humboldt and Dr. Fowler, thought that such test could never give a fair solution of the question since it is almost impossible to eradicate all nerve fibrils from muscle fibres. They, therefore, were led to conclude that irritability is a property of nerve and muscle as a compound structure.

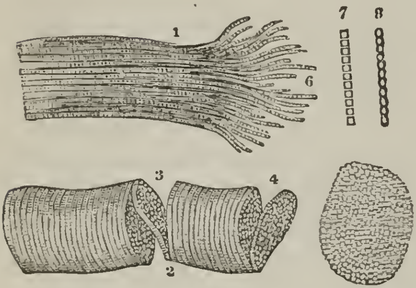


Fig. 49. A View of Elementary Fibres of Voluntary Muscles; i. e., of animal life, magnified three hundred diameters, showing a cleavage under *strain*, both lengthwise and transverse. This also shows that lameness from *strained muscles* may result from ruptured fibres.*

Dr. Marshall Hall announced the same opinion some fifty years afterwards.† Whether the property of irritability belongs to the pure and isolated muscular fibre, or to the muscle fibre *combined* with the nerves, he thought, could not be positively determined by distinct experiment; and that irritability belonged, in all probability, to the compound structure.

The *law* of Valli and Ritter, which is a confirmed fact in pathology, is in truth the greatest hinderance to determining this yet unsettled question. That law is, " The nerves *may* die in

* 1. The longitudinal cleavage, also showing the molecular structure.

2. The transverse cleavage.

3. Incomplete fracture of a muscle fibre, following the opposite surfaces of a disk, which stretches across the interval, and retains the two fragments in connection.

4. Shows another disk, nearly detached, as often seen.

5. A detached disk of molecules, still more highly magnified, showing the sarcous element of muscle fibres.

6. *Fibrillæ* separated by the effects of violence from each other at the torn end of the muscle fibre.

7, 8. The two appearances, commonly observed under the microscope, by the single *Fibrillæ*. At 7 they are more highly magnified and appear rectangular; but at 8 the borders are rounded, and the spaces are bead-like.

† Cyclopædia of Anatomy and Physiology, vol. iii. p. 29, 1847.

a direction from the centre towards the periphery;" i. e., the large nerve trunks sometimes are annihilated, as from a central lesion, before the branching twigs; and therefore, while the trunk of a nerve may have lost all excitability, still the fine ultimate nervous fibrils, that so minutely ramify the muscular tissue, may have as yet retained more or less of their susceptibility to an adequate stimulus. M. Claude Bernard,* of Paris, has recently removed a great objection to the Hallerian irritability, as is thought; for he shows that the motor nerves lose their excitability from the centre to the periphery *only in case* they have been previously separated from their nervous centre. When the sciatic nerve has been cut off from its connection with the spinal cord, severe galvanization of the trunk of that nerve will, after a given time, cause no more contractions in the muscles; but if we now transfer the galvanizing to the branches of the nerve in the muscles, and near the periphery, some contractions will still be brought about. But if, on the contrary, the nerve had not been cut or otherwise severed, but had remained still in its normal connection and physiological relation with the spinal cord, quite different phenomena are observed: the nerve now loses its properties in the inverse ratio; i. e., *from* the periphery towards the centre. If the crural nerve of a frog is laid bare, and no more contractions are excited by galvanizing the nerve in or near the muscles, still are contractions produced, if the galvanizing is done near the cord; and if the whole nervous trunk has lost its excitability, contractions can even then be brought about by galvanizing the anterior root of the nerve near the spine. It is in this way that the nerves lose their excitability, if animals die either from hemorrhage or from *woorara*. This can be illustrated by taking a frog, and first cutting the lumbar nerves on the right side, then let the animal be poisoned by woorara. Now we shall observe that the nerves lose their excitability in the direction from the centre outward to the periphery on the right side, where the nerve was cut; but on the other side of the frog the nerves die in the direction *from the periphery*

* Leçons sur la Physiologie, Paris, 1858, vol. i. p. 193.

towards the centre — i. e., where the connection of the nerves was intact. Therefore the terminal branches of the nerves are presumed to be the first which are destroyed by the poison of woorara; and as, in spite of this destruction of the properties of these terminal nerve fibrils, the muscles still show a ready response to the galvanic stimulus, the existence of the Hallerian irritability is claimed to be proved.

Mr. Bowman, of King's College Hospital, London, has arrived at what he claims to be equally unanswerable conclusions, but in quite a different way. He appeals to direct microscopical observations, made on *living fragments* of the elementary fibres of voluntary muscles, which he had entirely denuded and insulated from every vestige of other substance, whether nerve or vessel, so that he had nothing but the pure muscular fibre.* He observed that if, by design or accident, a particle of foreign matter was included in the field of the microscope, so as to be seen to touch the side of the fibre at a single point, the fibre there exhibited a contraction, that was limited to the point so touched, and not involving the whole muscular substance. Hence Mr. Bowman concludes that the muscles *do possess* an irritability proper, capable of being brought into action by a stimulus topically applied. It is obvious, says Dr. Althaus, that this observation of Mr. Bowman is of paramount importance, and that it greatly contributes to decide this question.

M. Claude Bernard undertook another series of experimental researches on the physiological action of the woorara poison, which also throws light directly upon this subject. He took two prepared frogs, and poisoned one of them by inserting under the skin a small bit of the woorara. At the end of five or six minutes the frog ceased to show signs of life, and the poison was then withdrawn, and a galvanic current caused to traverse a portion of the lumbar *nerve* of each of the frogs alternately. The muscles of the frog which *had not* been poisoned were immediately seen to show a powerful contraction, but not the slightest twitching occurred in the other frog. But when the

* Dr. Althaus on Medical Electricity, London, 1859, p. 129.

electrodes were applied *directly to the muscles*, both frogs suffered commotions, and it even appeared that the poisoned frog preserved the property of suffering contraction from the stimulus *for a longer time* than the one which had not been poisoned. This is claimed by some as very conclusive evidence of the actual existence of an irritability proper of muscles. But M. Eckhard objected to this conclusion, as it was not quite certain that the last ramification of the nerves were thus totally paralyzed.

Dr. Althaus says the following experiment satisfies his mind that the motor nerves, and those only, are first killed by this poison: He securely ties the crural artery and veins up on one side of the animal, so that the circulation of the blood in that limb is stopped. The animal is then poisoned by inserting a small quantity of woorara under the skin on the body. If, then, the motor nerves of the animal be tested by galvanism a short time afterwards, it becomes evident that all the nerves have lost their integrity, with the exception only of the crural nerve of that side where the vessels have been tied. This nerve, however, when galvanized, still sets the muscles in play. But if the electric stimulus be directed to the muscular substance itself, contractions may be obtained in all the muscles of that limb; and the contractile power of those muscles the nerves of which have been poisoned will last even longer than those which have not been so poisoned, in consequence of the stoppage of the blood circulation. He mentions in this connection, also, some microscopic observations of Dr. Wundt, which also go to show the irritability proper of the muscles. He saw that when the circuit of a galvanic battery was closed, embracing the muscular tissue that was in the field of the microscope, the fibres were shortened, and that, after the contraction produced by the commencement of the current had passed off, the fibres were still shortened; i. e., they did not immediately regain their previous length while the current was running, but remained somewhat shorter for several minutes. If the circuit was then opened again, there was a difference, in proportion as a contraction was produced or not. When there was no contraction at the cessation of the current, the muscular fibres immediately regained

their previous length; but if there *was* a contraction, the fibres appeared, after the contraction had passed off, to be even longer than at first. Dr. Althaus concludes, therefore, that the inherent muscular irritability has been fairly proved, —

First. By the microscopic observations of Mr. Bowman, showing at least a partial contraction of muscular fibres, which he concludes to have been *entirely isolated* from every vestige of extraneous tissue.

Second. By the peculiar experiments of Bernard, Kölliker and himself, by means of woorara, which, he assumes, does kill the motor nerves, while it leaves the muscles intact.

Third. By the microscopic observations, also, of Dr. Wundt, which show an action of the closed continuous current upon the muscular fibre when the electrodes are applied directly to the muscles; but no such action is obtained if the stimulus be conveyed to the muscles through the nerves.*

Thus it is evident, he says, that by the electric current the molecular equilibrium of the muscles may be directly disturbed just as absolutely as the molecular equilibrium of the nerves; for as soon as the equilibrium of either motor-nerves or muscles is disturbed, contractions in either case, or both cases, are observed. But the contraction produced by applying the electric current directly to the *contractile tissue* of the muscles presents, however, certain peculiarities which are important to be noticed. If the current be directed to a motor nerve, *the whole substance* of all the muscles which are animated by that nerve enters into simultaneous contraction. But, on the contrary, if the current be applied directly to a muscle, then only those fibres, or only a part of a muscle, are observed to contract which are actually traversed by the current. He says, if we wish to produce a contraction of the whole substance of a muscle, the electrodes must be placed one at the upper and the other at the lower end of the muscle. Besides, a current of greater intensity is actually required, if we wish to produce muscular contractions directly; i. e., without the intervention of nerve trunks. Hence

* Die Lehere von der Muskelbewegung, Braunchweig, 1858, p. 122.

we may conclude, he says, that the nervo-electric polarity of the *motor nerves* is more easily disturbed, at least by the electric current, than the molecular equilibrium of the fibres of the muscles. But my own opinion is, that electro-muscular contractions are most readily obtained; i. e., with the least pain, and by means of a less current, and that more uniformly, if we place one electrode over the nerve trunk, while the other electrode is made to glide along nicely and obliquely over the farther side of the muscle — a manœuvre which is readily learned, but not so easily described.

Electro-Physiological Researches and Creeds.

We said in the chapter of history that Volta objected to the theory of Galvani; but, at the same time, we find he took up these nervo-electric phenomena, first discovered by Galvani, as a nucleus of vast significance; and he, therefore, made them the subject of his most rigid investigations up to 1800. First, we see, it was reserved for him to show that the metal are employed by Galvani to produce the muscle contractions was not a simple *conductor*, but as being in and of itself a source of electricity, because it consisted of two dissimilar metals. From this stepping stone, placed for him by Galvani at first, Volta becomes the discoverer of the *electric pile*, which bears his name, and also the author of the *contact theory*. After this, the great object of his life seems to have been to show the correspondence in every particular between the *contact current*, as he then termed it, and the electric current, obtained by the friction machine, then already so well known. There were, however, those who doubted. In this connection, we may see motives which lead Volta to seek to prove, by every possible means, "the identity of the electric and galvanic fluid."

Volta also endeavored to remove all those theoretical difficulties which were presented, arising from the steadiness of the working of the closed pile, as it was then understood. Although uninterrupted chemical workings, as the decomposition of water, for instance, was very probably known to him, yet when refer-

ring to the action of the current *in the living body*, he says, "Only within certain limits, the definition of which would be difficult, does the continuous working of the current on the organs become at rest; for the minute shocks, or blows, which are like rapidly repeated sparks, following one another almost, if not quite, without interruption, in some way or another mingle into one single prolonged blow, as, indeed, I have heretofore tried to explain."

In the above quoted passage, evidently Volta advances the idea that the contact, or first flow of a current from a closed circuit of a voltaic pile, consisting say of one hundred pairs, is not simply and absolutely one blow or shock, but is an impression made *as one* out of one hundred blows or shocks, which follow each other so rapidly, yet in actual succession, that they mingle together *as* one shock.

Another instructive deduction of Volta's, in this connection, is found in the following: "What applies in effect from the action of the voltaic current, to the sensitive parts of the body, does not also in like manner apply to those endowed only with irritability. The muscle, for instance, shows only a quick or instantaneous together-drawing (when either touched itself directly, or through its nerve by the current) at the instant of contact, or closure of the chain, which is sometimes also observed at the opening or breaking of the chain, and which is the reason that the chain must be now and then opened and closed, if we wish to produce sensible action in contractions. But this must not lead us to suppose, that the closed current which flows quietly and imperceptibly on through the muscles and their nerves, is not affecting them; for they do become, from a long-continued action of the current, on the contrary, in some degree or sense paralyzed, although they appear to be in no way changed, nor even disturbed in structure."

In a letter to the Right Honorable Sir Joseph Banks, which is found recorded in the Philosophical Transactions, London, 1800, Dr. Volta says, that when he introduced the poles of a pile of thirty to forty pairs into the external opening of his own ear, he felt a shock to his head, and some moments afterwards

he heard a sound, or rather a noise, like scratching and bubbling, or like that of a viscid substance boiling. This noise was continuous and without interruption, becoming even more and more intense until the circuit was broken."

It was the muscle contractions that were observed at the closing and opening of the circuit, and particularly the latter, that attracted the greatest attention from Dr. Volta. He erroneously supposed the latter to be due to a sort of counter-current from a kind of induction, that flowed back on the instant of opening the circuit. M. Lehot, in 1801, modified this theory of Volta's, by laying down the proposition, that during the passage of an electric current through a nerve, a part of the *accumulated* electricity in the nerve and muscle, at the interruption of the continuous current, flowed at that instant in the opposite direction to which it entered, and so giving rise to the contraction, the same but in less degree as when the current was first closed. This was also erroneous. But the illustrious physician and philosopher Volta gave to these phenomena the term "*opening and closing convulsions*," and which are often found referred to by writers. It was Dr. Luigi Galvani, of Bologna, who first discovered that kind of contraction of the muscles of a frog that constitutes the *closing convulsion;** while it was Dr. Valli, another Italian philosopher, who soon afterwards made the discovery of the *opening convulsion.*† But after all, we can go a long way back of all this to find *the first tangible case recorded of the physiological effects of galvanic electricity;* for, in a paper published by M. Sulzer, in the Reports of the Berlin Academy of Sciences, in 1754, he says, "If a piece of lead and a rod of silver are connected with each other, and approximated to different parts of the tongue, a sensation of taste is experienced which resembles that produced by the vitriol of iron; while, *if we employ either of the metals alone, not the slightest taste is perceived.* It is probable, therefore, that *by the connection of the two metals*, a vibration is produced in the smallest particles, either of the lead, or of the silver, or in both

* De Viribus Electricitatis in Motu musculari Commentarius. Bologna, 1791.

† Reinhold, Geschichte des Galvanismus, etc., 1792.

of them; and that this vibration, which must necessarily affect the nerves of the tongue, produces the taste described." It was received as a curiosity.

The first systematic work upon *medical electricity*, including the employment of galvanism, was from the pen of a German physician — Dr. Grapengiesser, of Berlin, in 1801. It appears that his work was not the mere production of theory, but was "the result of his practice," and more particularly of the considerable success he obtained. He advises the employment of the voltaic current of electricity in amaurosis, and in cases where there is a premature decline of vision from want of nerve power — for tumor albus, for rheumatisms, for sciatica, and for palsies. In these latter affections, *it was his practice* to place the *positive pole* over the trunk of the nerve that supplies the affected muscles, while the negative pole is placed lower down on those affected muscles; thus he employed mostly the continuous voltaic current with *rare* changes or interruptions. He also speaks of using it successfully in deafness, and in hemiplegia, *after the cessation of the pressure in the brain*, and in all other paralytic affections and conditions. He seems to have resorted to a species of reflex action; for he speaks of using wooden basins filled with water, into which the electrodes, together with both the feet, or the two hands, of the patient are plunged. Of course, one limb receives the negative current as up-running, while the other limb is receiving the current down-running towards the positive pole to form the circuit; and these he *alternated* according to the case.

His general method, in nearly all other cases, seems to have consisted in drawing two blisters, and applying and retaining a single pair of silver and zinc plates *immediately upon these raw surfaces*, the cuticle being first removed. This, indeed, had been recommended, by Alexander von Humboldt and others in those times, as the most direct and effective method of using galvanism; and certainly it was a "localized method" with a severity, for we also see mention of "several hundreds of pairs of plates" in the pile employed, and also of "a hundred blows given at a *seance*," by the opening and closing of the circuit, through these *raw surfaces*.

There was another work, published by Dr. Richard Fowler, on "Experiments and Observations relative to the *Influence* lately discovered by M. Galvani, and commonly called *Animal Electricity*," in Edinboro', 1793. This English work contains very many curious and also interesting facts, showing how the case appeared at a distance in those earlier times of its history.

Still another work may be mentioned, among the many that were put forth in England, which was by Dr. Wilkinson, in 1804, entitled "Elements of Galvanism," which contains much good hard sense in connection with this subject. Dr. Wilkinson found that two pieces, one of silver and the other of zinc, each presenting a superficial surface of only a hundredth part of an inch, produced violent contractions in the leg of a frog prepared after Galvani's method. At the same time he found that two circular plates of zinc and copper require to be brought twenty times in contact with the condenser of the best electrometer then to be had, before any sensible divergence of the gold leaves of that instrument was produced. By comparing the area of these plates, multiplied by the number of contacts, with the superficial surface of the minute pieces of silver and zinc employed to effect the muscular contraction of the leg of the frog, he arrived at the conclusion that the sensibility of the fresh-killed frog to electric currents is many thousand times greater, — or, in other words, more delicate as a test of electric currents, — than any of the most sensitive electrometers.

It is worthy of notice, also, that the earliest and most distinguished observers of these electro-muscular contractions mention the fact that the convulsions, as they were usually called, were more promptly and strongly produced *after* a certain number of electric treatments, — and that by means of only a single pair, — than they were when first applied; and that all the more marked if a moderate current was employed than when a very powerful current was used. Alexander von Humboldt made analogous observations from *ad hominem* experiments which he caused to be conducted upon his own shoulders. After having removed the cuticle on each shoulder by means of a cantharides

plaster, and exposed these raw patches to the *immediate* action of a pair of silver and zinc plates, he speaks of the effects in this manner: "As torpid or long-dead frog-thighs, *at the commencement* of galvanizing, twitch hardly any, if at all, but, after being brought for the third or fourth time in contact with the electrodes of a closed chain, the twitchings become lively, just so have I observed distinctly on myself that the first blows or shocks of a moderate current produced only a dull sensation, which, however, was perceptibly increased in degree, so that, from the fourth to the sixth contact of the connecting wires, they were of greatly augmented force. Does here the stimulus itself increase the excitability of the organs so that by the fourth to the sixth blow, while the irritation remains the same, the *susceptibility* is become increased, or is the excitability not exalted, but, on the other hand, is the irritation aggregated in the muscle fibres? Of these two suppositions, I am inclined to think the first as the most probable."

Immediately after these declarations, M. Ritter, first of all,* by experiments observed that the closed chain does, indeed, alter the excitability of a nerve and muscle; for a steady current traversing a prepared leg and nerve of a frog, either through the nerve alone or through the nerve and muscles both, and for a long time, — say from half an hour to an hour, — will exercise an influence to change or decrease the irritability, so far as it shows itself by opening or closing convulsions. But the *direction* of the current employed produces very different results; and that,—namely, the down-running if a continuous current,—renders the thigh of the frog, in the course of an hour, incapable of showing either closing or opening convulsions, if the same direction of the current is used; but by then using the up-running current, there will not only be produced, (after a half hour, or even whole hour,) at the opening of the chain, very strong twitchings, but it will even afterwards occasion tetanic contractions, which can also be dissolved again by closing the chain. Thus two frog-thighs may be treated simultaneously in the same

* Beweis dass ein selbeststandiger Galvanismus, etc., Weimar, 1798.

manner, but the current must be running up in one while it is running down in the other: now, if these are alternately changed from hour to hour, — i. e., simply reverse the direction of the current, — each of them may be put in the same condition in which the other was the hour before; and these alternations can be proceeded with for a whole day, or until the excitability gradually decreases away. Again: if both arms of a person are exposed to a *powerful* current, and for a long time, — say half an hour or so, — there will be experienced, in the one in which the current runs up, a feeling of increased mobility; while in the other, where the current runs down, there will be a sensation of heaviness or lameness felt. M. Ritter afterwards corrected these propositions by saying that the exaltation caused by the up-running current does not always appear, but only now and then, as when weak currents are employed, but never when strong currents are used; and after employing a powerful current for a long time in either direction, there will be produced a depressing influence — i. e., as a general thing, make the excitability of a muscle or muscle-nerve thus traversed for a long time to decrease faster than would take place in the already dead frog if left to itself.

It must be borne in mind that the above statements, and also the corrections, all date from a time when M. Volta had already published his observations on the alternated actions of the current, and which he had reached by quite another process. These facts I record because "the alternations of Volta" and "the alternatives of Ritter" are so frequently referred to by the older writers in this department of medical literature.

Soon after Galvani's classical experiment (see page 72) had been made known, Dr. Volta was the first to notice that the electro-muscular contractions take place, if only a *portion* of the nerve is alone enclosed in the circuit, not transversely, but *lengthwise*, and that without touching the muscles with the electrodes, or even including them between the poles of the circuit. This led to a flood of trials, which were immediately instituted by Volta, Ritter, Pfaff,* Lehot, Humboldt, Valli, and Galvani;

* Uber thierische Electricital und Reizbarkeit, Leipzig, 1795.

and then, still later, by Nobili, Marianini, and Matteucci; and then, again, more recently, by Dubois-Reymond, Faraday, Marshall Hall, Becquerel, Duchenne, Todd, Bird, Remak, and Althaus. The larger class of those early experiments was directed mainly to ascertain *the law of current direction* and *the law of convulsion.*

It was very soon observed that the nerves of the batrachian tribe, — those famed martyrs to science, — were so sensitive to the electric stimulus that *only* the more gentle currents of the pile could be employed; for if the current was strong, whether up-running or down-running, the commotion was so great that the real difference could not readily be observable. M. Pfaff early drew attention to the particular difference in the phenomena that presented on running a mild current *up* or *down* a nerve; for if the current of a powerful pile be used, no such differences would be uniformly observed. But by using the current of a single pair of steady and continuous action, we observe the following: Where the frog is vigorous and but recently killed, and the nerves of the prepared legs are consequently in the highest degree of excitability, we usually see contractions both at the closing and at the opening of the circuit, and that whether the current runs down or up. But if, after a longer time, or by repeated teasing with the galvanism, the legs and nerves have lost a part of their excitability, then a very marked difference is noticed in the physiological effects. Now, if we first direct a down-running current through the ischiatic nerve, the contraction, which is a mere momentary twitch, is observed *only at the first moment* the current is applied, but not while the current continues to traverse the nerve, nor yet at the moment when it ceases to pass. But if an up-running current be applied to that nerve, with say a half-inch space between the poles on the nerve, just as in the former case, we observe there are *no* contractions at the first moment the current is applied, nor yet while it continues to traverse the nerve, but *only* at the moment when the circuit is broken, and the current *ceases* to pass.

Again: if we employ in these researches the united pair of

legs of a frog prepared after the original manner as done by Galvani, and immerse the two legs respectively in two glass vessels which are nearly filled with water, and now plunge a pole of a weak current into each of these vessels, we notice that contractions do not take place in each at the same time, provided, always, that the legs have lost some of their excitability, so as to make the differences more distinctive. Now, a contraction will be observed, on *making* the circuit, in that leg in which the current is *direct* or down-running; but it will be on *breaking* the circuit in the other leg in which the current is *inverse* or up-running. Then, if the irritability in the preparation be allowed to be still further diminished by time, or by treatment for experiments, only one kind of contraction will remain, namely, that first produced by *making* the direct current at each time; if the irritability be still further diminished, all contractions or twitchings of any sort whatever will disappear.

If a gentle, continuous current be applied to a nerve, the nerve will retain its excitability very long, — i. e., to the touch of a reversed current, — and will not be injured as much as is done by applying moderate mechanical or chemical stimuli. But if the continuous current be of great *quantity* or *high* intensity, — if, instead of a single battery, there is employed a large size series, or if, instead of a single pair, there is employed a numerous pile, — then, just as we might expect, the nerve will be destroyed by the chemical action at and about the electrodes.

Finally, as I have said, Nobili gave these differences of contractions, which so elicited the early attention of philosophers, a most elaborate series of investigations. He concluded, finally, that there were *five* different stages, kinds, or *degrees* of contractile *response*, in nerves and muscles, to the same given strength of electric current. But we now conclude that some of those differences that he found, arose from experimenting on *dead frogs*, not on living animals or men, and that the difference in results obtained in those early times, by equally honest experimenters, mostly arose from using widely different electric apparatus and currents, as to *quantity*, *intensity*, or the given *density* of the stream employed.

M. Matteucci not only corroborated from his researches the "*current proper in frogs*," noticed by Nobili, but also discovered and demonstrated in man, and all warm-blooded animals, *the existence of a natural muscular electric current.* By cutting the muscles of a living animal, and thus introducing into the wound the nerve of the fresh prepared *frog-galvanoscope*, so that the end of the nerve touched the very bottom of the wound, whilst another point of the same nerve touched only the edges of the wound, he obtained a decided contraction. This, he says, was fair proof of the existence of a natural electric current, directed in the muscles from the deep interior of their body to the surface. This experiment we have often seen succeed, if only nicely conducted, whatever be the kind of muscle, or whatever be the animal whose live muscle is so touched, even where the muscle of a warm-blooded animal has been separated from the live animal for some time. But to magnify the effects produced by the native electric current of animals, M. Matteucci increased the intensity of the animal electric current, by *uniting* a series of separate muscles, much as we form a voltaic pile. Thus having prepared, by cutting smoothly a number of half thighs of frogs, he arranged them in regular order, so that in each point of contact of half thigh to half thigh, exactly in the same order of direction, it is, on the one hand, terminated by the interior of the muscles, and on the other, it is terminated by the exterior or surface of the thigh. Then these two extreme ends are placed in communication with distilled water, into which are now plunged the terminal platinum ribbons of a sensitive galvanometer; i. e., after being quite certain that they do not transmit any other current before the flesh is included in the circuit (as a battery) to be tested. Immediately there is obtained the evidence of a muscular electric current, and that always directed from the internal to the surface of the muscles,—the intensity of which varies according to the number of half thighs of frogs that compose the given pile; as, for instance, 3° to 4° are observed, indicated by the needle from two thighs, 6° to 8° from four, 10° to 12° from six half thighs, and so on.

Animal Electricity as observed in Fishes.

The Romans employed a certain fish, centuries ago, *that gave shocks* for the cure of inveterate headaches, and for rheumatisms. The electric fish that was known to them must have been the *torpedo*, as this very remarkable fish is now found frequently in the Mediterranean Sea. M. Walsh, in 1778, made a series of systematic experiments to ascertain the nature of these shocks, as then the Leyden vial was already known, and it was surmised

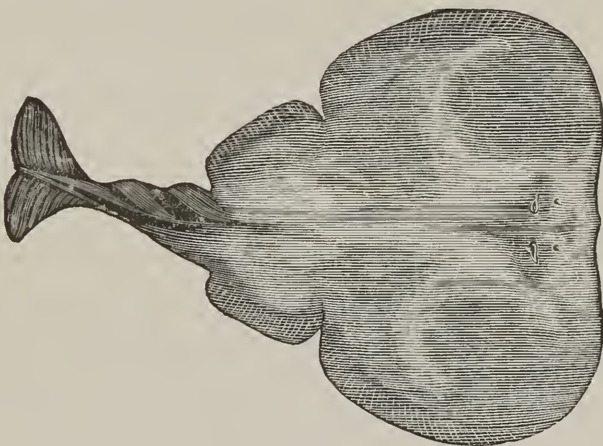


Fig. 50. The Electric Torpedo of the American Atlantic Coast.

that the "fish phenomenon" was the result of electricity. He soon ascertained that the shock was prevented by any electric *non*-conductor, as glass or wax, while the shocks were received when the fish was touched *immediately* with the finger, or even by a rod of metal. He transmitted the shock of a vigorous, recently caught fish through a circuit of twenty persons, who formed a chain by holding each other by the hand in the ordinary way, as was practised with the Leyden jar.

In the Transactions of the American Philosophical Society, held in Philadelphia, in 1786, as recorded in volume second and number thirteen, it is stated by Mr. Flagg, that if a number

of persons join hands, and then one of the number touches the electric eel, they are all equally shocked, unless some one of the number is peculiarly incapable of being affected by this fish; for there was one person, he mentions, who was a most worthy lady acquaintance of his, who could handle this fish at her will; but, he says, the lady was at the time an invalid, laboring under a hectic fever.

The electric fishes, now well known to scientific men, are five kinds or more, — the *Ray Torpedo*, the *Gymnotus Electricus*, the *Silurius Electricus*, the *Tetraodon Electricus*, and the *Trichiurius Electricus*. Gay-Lussac, Baron Humboldt, and Davy were the next to test and publish the circumstances of these *shock-discharges* of the torpedo. Humboldt proved that the discharges of the gymnotus are determined from its brain, and that they entirely cease when the four great nerves leading from the brain of the fish to its batteries are cut across, or when the brain is removed; this evidence is also obtained by an irritation of its spinal marrow, which is all the more significant, since the nerves of the *electric organs* of this fish come through the spinal marrow.

From the earliest times the ray torpedo has been the object of wonder for fishermen and sailors, as being able to give a dreadful shock either to defend itself or to kill the little fishes necessary for its food; and this property was by them often wonderfully magnified, or even imputed to various *larger* fish, which was the embellishing of their stories for centuries. This fish is flat, short, and broad, with a brown back and white belly, apparently swimming and living near the sandy bottom of the sea or harbors, much as do our flat fish, flounder, or halibut. But the body of this fish terminates with a more fleshy and short tail than the largest flounder. The space between the pectoral fins, the head and the gills, is quite filled, except in the very middle, with an extraordinary apparatus, called by physiologists, the *electric organs*. These are formed of small membranous tubes, placed perpendicular in the animal, reaching from the belly surface to the back surface, and are packed one against the other in the utmost order of regularity, as to economy of

space, presenting six sides to each column or pile, much as is seen in the wax comb of the honey bee. Then each of these perpendicular tubes is minutely subdivided horizontally, by membranous diaphragms, into thin cells, which are filled with a kind of mucous secretion; and these again are traversed by a fringe of nerve filaments that come from the great eighth pair of nerves. According to Dr. Hunter, the torpedo has at each side, on an average, four hundred and seventy hexagonal tubes, averaging one and a half inches long each, — making in all nine hundred and forty piles. Each of these, he says, has a surface of two thousand diaphragms, and between the minute spaces of these exceedingly thin and simple membranes, there is a liquid, as we have just remarked, of an albuminous nature, (nine tenths water, a trace of salt, and one tenth albumen.) These all are animated by four large bundles of nerves, which arise in the brain, and are distributed throughout all the electric apparatus by multitudinous ramifications, until they are lost in the minute substance of all the diaphragms, but terminating *exactly alike* upon the same side of each diaphragm.

But the *electric organs*, in all these fishes, are not exactly alike in arrangement, but are similar as they are in structure. Alexander von Humboldt has given a most graphic description of the gymnotus, or *American electric eel*, — also called the Surinam eel, because there found most plentifully. He relates that these fishes may kill a horse or mule at a blow; and, consequently, a long time ago, it was found necessary to change the trail from Uritucu, through the steppes in South America, because these great electric eels had accumulated in a stream on the former route that had to be forded. He says, that year after year, a great number of horses were benumbed, while crossing the stream, by these fishes, and were thus lost by being finally drowned in this passage. We have just seen that in the flat fish torpedo, there were nine hundred and forty piles of two thousand series each; but in the *electric eel* the tubes or piles do not stand perpendicularly, but are laid horizontally from head to tail, longer and less in number. This is, therefore, the most powerful electric fish known; just as we might expect judging from

the practical laws of the voltaic pile. This is admirably illustrated by a comparison with the Pulvamecher's chain, showing the relative value of numbers *consecutively* alone considered, and numbers consecutively in *series*, with a due proportion of surface, or force in each. This higher philosophic arrangement we see more nearly consummated in the electric eel. The torpedo fish being, as we have seen, flat and thin, the piles are necessarily perpendicular and short, reaching from its belly to its back, are very much shorter, but nearly five times more numerous consecutively than in the eel, for there are 1,880,000 diaphragms or elements, while in the Surinam eel, or gymnotus, there are only 384,000 diaphragms or elements in all. But in the eel, the animal being slim and long, the piles are laid horizontally, and each contains four thousand diaphragms, although there are only ninety-six series of tubes or piles. These lie from head to tail ; hence less piles are required to accomplish the same object, for each pile has a relatively larger battery surface. The electric eel, I should have said, is some five or six feet in length, and is a more powerful fish than the torpedo, as to muscular strength.

Faraday says the shock of the gymnotus, which is, by the way, a fresh-water fish, is from its natural action in the water found to be directed from its head, which is positive, to its tail, which is negative. According to De la Reve, the shock of these animals is produced only by the will ; for they can discharge *when* they choose, but not *where* they choose exclusively, for all the water for several feet about them is at once affected.

More recently, Matteucci, Savi, and Kölliker, have experimented with some of these fishes, and deduced many instructive facts. John Davy, brother to Sir Humphry Davy, succeeded in magnetizing steel needles, and even deviating the needle of the galvanometer, by repeatedly placing in contact with the two faces, i. e., top and bottom of the torpedo, the two extremities of a wire wound into a helix, or by employing the two platinum extremities of the galvanometer itself. He thus ascertained that the upper surface of this fish is *positive*, and that the lower

is *negative.* The quantity of electricity liberated in any of these fishes is found to be in direct proportion to the energy of its circulation and respiration. They can effect their discharges in the air, as in the water; for, if held in the hands, the shocks are so intense and succeed so rapidly, that it is impossible for most persons to endure it. But then the fish soon becomes weary, and it is necessary to replace it in its native element of fresh or salt water, and allow it to have a long rest, as well as nourishment, to enable it to regain its accustomed power for shocks. We must readily see the resemblance between this arrangement of nature and the artificial voltaic pile; indeed, the electric organs of all these animals constitute veritable, as visible, living voltaic piles, without metals, it is true, but possessing the arrangement of positive and negative surfaces, as if Volta himself had copied them, or they had been constructed on the voltaic plan.

Professor Colladon has still more recently observed, by a capital experiment directed to that end, a very instructive fact, which, it is true, M. Matteucci and others had observed in a less direct manner. He placed the two terminal platinum electrodes of a very delicate galvanometer, the one to the under surface of the torpedo, and the other to its upper surface, immediately after the fish had been exhausted by the effects of repeated excitations and discharges. He then wounded the fish, by cutting deep and successive gashes in its flesh. These gave no results. Next he thrust the point of his penknife into the substance of the cerebellum of the torpedo, when he instantly saw the galvanometer needle fly completely around. This experiment he repeated, by using a sharp point of ivory, in a fresh torpedo; and this was attended with exactly the same results, which prove conclusively the large influence of the living *brain* and *nerves*, in producing the development of tangible electricity in these fishes. That the electric power of the *Surinam eel* resides in the brain, was first proved by Baron Alexander von Humboldt. Father Linari, it is said, has succeeded in producing veritable electric sparks between the surface of some quicksilver that communicated by means of a conducting wire

with one of the surfaces of the torpedo fish, while an *iron* wire communicated with the other surface of the fish to retard the current.

Place has thus been given to this chapter on *comparative electro-physiology*, as observed in the fishes, not as a mere matter of curiosity, but as the more simple and powerful demonstration of *fundamental facts* relating to this department of science; and for the same reason we shall admit the testimony of other phenomena, as observed in the batrachian tribe, and in the dog, rabbit, and other animals, before we come to examine *pre-trials* in the living human organism.

"*Animal Electricity*" *as observed in Man, but more plainly illustrated in Animals.*

Actual trials show that the artificial section that is obtained by cutting a living muscle transversely with a very sharp instrument gives exactly the same result, as to animal electric currents, as the transverse test of the muscle while intact. In fact, almost no current is obtained upon placing lengthwise, between the poles of the galvanometer or the galvanoscope, simply the *middle* portion of red muscular flesh, cut clean and transversely from all its tendonous attachments at the two ends, and stripped of its investing fascia. The same negative results are obtained likewise if the clean platinum tips of the galvanometer touch only the tendonous extremities of an entire muscle. But, on the other hand, a very decided effect is obtained by placing in contact on the one side an artificial transverse section, and on the other the longitudinal section of the muscle,—the course of the current being found always directed in the muscle *from* the transverse *to* the longitudinal section. De la Reve, therefore, sums up the *law* of the muscle current by stating that each point of the natural or artificial lengthwise section of a muscle is positive, in respect to the points of the transverse section, whether natural or artificial, and that the points that are the nearest to the centre, in all respects, are negative with respect to all those which are more distant.

From the above and other facts, we deduce that the phenomena of animal electric currents can only take place in a living organic tissue, and which, when once it has disappeared by *rigor mortis*, cannot again be produced, even when that rigidity has ceased. This is, indeed, a further proof that muscular electro-motive force, is very dependent upon the arrangement the *vital influence* imparts to the organic molecules in the ultimate structure of the muscle fibrils, — an arrangement that in various degrees endures for some little time after death, as also does irritability, but which disappears forever, as soon as decomposition sets in, and the particles are no longer subject to the laws and force of vitality, that so absolutely rule in and over organic matter. M. Matteucci supposes this to decrease at death, and the more rapidly in proportion as the animal occupies a higher rank in the scale of beings. M. Dubois-Reymond attributes this difference rather to the fact that all warm-blooded animals, mammiferous, and birds lose their muscular irritability after death much more rapidly than fishes and reptiles, and other cold-blooded animals. He lays down, therefore, as a *rule*, that the diminution in the animal electric current after death is proportional to the degree of natural excitability of the muscles; and that the electro-motive force, as well as excitability, have for their termination the *rigor mortis*. M. Bruke has shown, that *rigor mortis* is the result of the coagulation of the fibrine contained in the bundles of muscle fibres *outside* the blood vessels, and that this state ceases when microscopic decomposition thaws it away.

M. De la Rive says,* "the arrangement that we assume to be imparted by the effect of the vital principle to the molecules that constitute the muscular fibre, appears to us to agree in a very remarkable manner with the statement, that the electric polar state, is due to a primitive movement of rotation, that each atom of matter possesses by endowment, around an axis, the two poles of which are positive and negative." We might conceive, he further says, that the vital principle would act by

* Treatise on Electricity, vol. ii. p. 49.

compelling the molecules, of which a fibre is constituted, so to arrange themselves exactly, that their movements of rotation are accomplished in them all in the same direction, around the same relative axis, in the whole bundle.

But of all the influences that are exercised over the native or natural muscular current is the contraction of the muscle itself. This is brought about by *nerve irritation;* as by the imparting to a motor nerve, and that, perhaps, first through a sentient nerve by physical, mechanical, or chemical means, a particular state that is usually manifested by a contraction. To effect this, the most reliable and efficacious of all means is the transmission of an artificial current of electricity through the nerve; and this is modified again most astonishingly by the *form* of the current, and by the *mode* of applying it, as well as by the *condition* not only of the nerve and muscle, but also of the central organs. Consequently, the greatest possible precaution is requisite to the correct employment of this agent *as a remedy*, by influencing, disturbing, and even determining the native muscle and nerve currents that are disordered. As an illustration, it may be stated, that the actual passage of every electric current of induction, through a nerve or muscle, is found to produce a degree of minute tetanic contraction, which may not always be visible to the naked eye, nevertheless is attended at first with a sudden change in the direction of the native current; then there is an oscillation, as manifested by the needle of the galvanometer, which then appears to be unable to come to a rest in any position of equilibrium so long as this artificial tetanic state endures.

This result, which was first pointed out by M. Matteucci, has been designated by him as the *induced contraction.* M. Dubois-Reymond appears to have demonstrated that this induced contraction, which he terms *secondary*, is only one form of manifested *variation of intensity* that the native muscular current undergoes, and that this deviation is a weaker one. To illustrate the existence of the muscular current in healthy living men, Reymond plunges all the fingers of both hands respectively into two vessels which are filled with salt water, but in-

sulated, and communicating only by the conductors of the galvanometer, and prepared with every precaution, so as to be deprived of all electro-motive force whatever. Then, when the needle has become tranquil, he contracts all the muscles of one arm as powerfully as possible, at the same time taking care to avoid the least movement of the other arm and fingers. At the moment of contraction the galvanometer shows an impulse, the intensity of which depends upon the strength of the subject and the adroitness of the operation; but the invariable direction of the current travelling in the contracted arm is *from the hand towards the shoulder.*

This reverse direction of the animal electric current he thinks can only be attributed to the diminution or exhaustion, or negative variation, as it is called, that is suffered by the native muscle electric current, and produced simply by the contraction of the arm; whence it is inferred that the natural current in the arm that was kept at rest preponderates; for before the trial, their respective animal currents balanced each other, because of their similarity. The natural animal electric current, however, of the human arms, during life and health, travels, in each of them, in the direction *from the shoulder to the hand;* i. e., *from the nerve centres to the periphery and extremities.*

It has been clearly demonstrated by Dubois-Reymond, aided by his exquisite Galvanometer-multiplier, that there exist in the *nerves*, as in the muscles, of man, perfectly determinate currents of animal electricity. This is as true of all the nerves as of the living muscles, whatever their respective functions, as well in the nerves of sensation as in the nerves of motion, in the anterior as in the posterior root, and in the mixed nervous centres as in those that are simple. The nerves of man and of animals in this respect present the same phenomena, and are subject to the same laws, as the currents in living muscles. The latter are supposed to be only the effect of the electric polarity of the ultimate nervous partitions, and of the arrangements which they assume under the all-controlling influence of the undefinable *vital force.*

Says a distinguished philosopher, it would be intensely inter-

esting to know exactly what becomes of the *native* normal or abnormal nerve current, in health and in disease, *at the time* when that given nerve is called upon to render to the muscles or to the nervous centres, those modifications that we recognize and manifest in sensation or motion. This, for a motor nerve, we conclude, is that which produces a degree of vibrating tension or tetanus of a greater or less degree in the depending muscle or muscle group; while, for the nerves of sensation, it is that which produces the most life-like sensations. These are best imitated and observed from the effects of induction currents of galvanic electricity. But first let us observe the result of the influence of a constant voltaic current over the native animal, muscular, and nervous current.

If we cause a feeble but steady battery current to travel *in the same direction* with the native nervous current, as through an isolated nerve, we immediately see that the latter is *increased;* while if the direction of the two currents are *opposed*, — the artificial to the natural, — then the native intensity is found *diminished.* Either of these conditions can be thus maintained as long as the projecting portion of living nerve experimented upon is traversed by the gentle, steady voltaic stream to certain limits; but they cease immediately when the latter current is removed.

It is thus determined that by means of the circulation of a foreign current through the trunk of a nerve, there is brought about an alteration in the entire nerve, even with its extended branches included. This alteration M. Dubois-Reymond calls the *electro-tonic state* of the nerves. It is also called *electrotonus.* He gives two forms or phases of this induced state of the nerves: the one is where the original nervous current receives an augmented intensity, which he calls the *positive;* and the other is where the nerve suffers diminution of the native nerve current, and this he calls the *negative.*

From the study of these phenomena, we may explain by supposing that the electro-tonic state which the nerve is caused to assume is due to the molecular polarization of the nerve, analogous to that which is always determined in all conducting bodies

from the one-way passage of any electric current. This polarization simply consists in the fact that the molecules of the nerves, naturally endowed, as they are, like those of the muscles, with two electricities, turn all their positive poles towards, or with the way the foreign voltaic current is going, while all their negative poles are towards from whence it comes. The molecules of the nerves are supposed to be bi-polar, and arranged as in muscles and other fibre. This explains the manifestation of the nervous current, which is in the same direction with the muscular current. But under the influence of the *exterior* voltaic current, the nerve molecules being more *mobile* than muscle molecules, they arrange themselves, one after the other, according to the true mode of polarization. This condition is assumed even in portions or *branches* of the living nerves that are traversed where these twigs *are not directly* traversed through by the current. This action is called *extra-polar working*, and has a tremendous bearing, as we shall have occasion to observe, on the every-day results obtained in systematic electro-medical practice.

There is obtained from these microscopic results and philosophic deductions *a law* that there results, from a foreign or galvanic steady current actually coursing for a given time through a nerve trunk, "*an abiding influence*," which causes an *increase* or *diminution* of the active native electro-nerve current, and that according as the artificial current was made to bear upon the nerve, whether directed *against* or *with* the native current — whether often or seldom *reversed* or *repeated*, or long *continued*.

Again: if the nerve is placed between two clean platinum plates which serve as the poles of a very gentle but finely interrupted induction current, and hence alternating in rapid opposite directions and in regular succession, there is a tetanization produced. On suspending this artificial current, after a short time we see that the galvanometer indicates a decided *diminution* in the nerve current proper in that living part, whatever may be the so-called direction of this exterior current; whilst, with the continuous and even stream of galvanism, continued for the same length of time, we get an *increase* in the living

electro-nerve current, i. e., when run in the same direction with it; but there is a *diminution* of the living electro-nerve current proper to the living organism in health when the artificial current is directed in the contrary direction, i. e., against the natural nerve current.

There is an important difference, then, to be observed between the tetanizing of a nerve and that of a muscle; the electrotonus in the muscle being the result of a weakening or a negative variation of the native electro-muscular current, whilst that in the nerves is connected with the appearance and the cessation of the electro-tonic state, which is alone produced and maintained by the rapidly interrupted, and as rapidly and regularly alternated, electric current of induction. M. Dubois-Reymond has shown in this connection that the electro-tonic state of the nerve, excited directly, determines also *in the neighboring* nerves and their branches an electro-tonic state; *but exactly the reverse of its own.* This has a significant remedial worth, to be borne in mind in connection with this practice, that comes under the head of *extra-polar workings* of the current.

It has been proved satisfactorily that whatever be the portion of any sensitive or motor nerve, that is positively polarized, there is immediately manifested a negative variation of the natural nervous current in all the remaining or unincluded portions of that nerve, — a proof that the new influence is propagated through all nerves in all directions equally. This solves the great question, whether, in each class of nerves, the natural nervo-galvanic current is propagated only in one given direction, as from above downwards in the motor nerves, and from below upwards in the nerves of sensation. All kinds of nerves, then, as we have shown, conduct electricity in the same manner when under the influence of the foreign, galvanic, or Faradaic currents. We can recapitulate and sum up the following condensed conclusions, much in the words of the great modern philosopher, M. De la Rive: —

1. We may regard as demonstrated, and that in a decided manner, from a multiplicity of prodigious researches, that there does exist, both in the nerves and in the muscles of all living

human beings, and in living animals, a *natural electricity*, under the influence of a *vital force* that is as ceaseless as life, and in some degree, at least, independent of mechanical, physical, or chemical actions, whether exterior or interior, although it co-works with them.

2. That this native or animal electricity is manifested under the form of closed currents, circulating along the course of the muscles, or along the course of the living nerves, but of which we are able to collect only the smallest *appreciable* portions by the assistance of our best instruments.

3. That the presence of this *free electricity* is subordinate to the state of the life and well-being of the person or animal, and that it totally disappears, together with the vital force and all vitality, at death.

4. That in the nerves, as in the muscles, there is an electric antagonism between the transverse course, which is negative, and the longitudinal, which is positive.

5. That a great and sudden diminution is observed to be brought about in the animal current of the muscles, at and after the moment of powerful contractions; and also in that of the native current of the nerve, at and after the transmission of a sensation or motion.

6. That the negative variation of the muscular current *is not permanent*, even when the contraction is so, or rather seems to be so, as in artificial tetanus — a state that is composed in fact of a rapid succession of simple and sudden variations of intensity; that the muscular current does not recover its intensity immediately, but gradually, and that after the contraction, or the electrotonus, has ceased.

7. That the electric phenomena in the nerves of motion, and in those of sensation, are for the most part identical; both of these kinds of nerves transmitting the artificial galvanic current of electricity in both directions equally well.

8. That the nerves differ from the muscles in their electric relation in that, when the former are traversed in but a portion of their length by a continuous current of galvanism, *the entire nerve* assumes an electric or *polar state*, which is termed

electro-tonic; whence results the production of a current that, according to its direction, either increases or diminishes the effect of the ordinary natural electro-nerve current. Then this electro-tonic state of the nerve, that may also be imparted to its depending muscles, is a commencement of electrolization; it thus brings about a contraction, both by its arising or appearing at the moment when the circuit is made, and then by disappearing again at the moment when the current is broken.

If now we compare together these facts, that are proved by our electro-physiological experiences thus far, we find that we arrive at some further very remarkable and valuable conclusions; and first, we observe that when we act by means of a strong, steady, primary current, upon the nerve trunks of a living person, then there is, at the very commencement of the trial, a contraction of the limb, and a manifestation of real pain; and this also at the moment when the circuit is broken, as well as at the moment when it was closed or made; and that these results obtain, whatever may be the direction of the current employed.

But on continuing these trials for a certain longer time,— shorter in proportion as the current employed is the more intense,— we find that there exists a difference between the effects, according as the current travels in the one direction or in the other, and according also as the circuit is closed or opened. When the current is directed *downward*, i. e., from the head and spine in the direction of the ramification of the nerves, the effect is limited to the contraction of the muscle, muscle group, or whole limb, *at the moment when the circuit is closed.* And when the circuit is again *opened*, the effects are limited, or mainly directed to the contraction of the muscles of the back, which are accompanied with pain. But if the poles of the battery are now reversed, so as to send the current in what is called the *inverse* direction, or *upwards* and towards the spine and brain, and thus contrary to the nervous ramification, then the order of the phenomenon is not only reversed, but also modified. The *closing* of the circuit now, causes the contraction of the muscles of the back, which is accompanied

with pain, while the *opening* of the circuit is attended with a contraction of the muscles of the limbs.

Thus there are found two fundamental states or periods of vitality in the nerves and nervous system of man, entirely independent of those states brought about by the prolonged or abusive use of different treatments, which, from the mere temporary action of the artificial galvanic current, gives two classes of results. In the first condition the current acts readily in both directions; that is, at the closure of the circuit, during the continuance, and at its opening. In the second condition, it acts mainly at its *commencing*, if running *with* the nerves, but at its *ceasing*, if running *contrary* to the nerves.

Again: if we find that a *stabile* and somewhat strong galvanic current is able to produce pain, together with contractions in the muscles of the back and head, and this even when the current does not act *directly* upon a nerve that ramifies into these muscles, thus, indeed, bringing about a motion at will, purely by the power and skill of the electric excitation of the nerve or nerves, situated *above* the excited part, then we conclude that this result must be due to that action which Marshall Hall has designated as *reflex*, or reflexion, — an action which is due, in the first instance, to the sensorial excitation of the nerve upon which the current *directly acts*, and this bringing about the contraction through the intervention of the nerve centres; as, for instance, from the periphery sensory nerves thus telegraphing back the answer through the motor nerves. And here lies the broadest and deepest channel for the introduction of those yet to be discovered electro-therapeutical operations. What we already know of them is not only invaluable in itself, so far as it goes, but is also rich in promise, though as yet, we believe, it has received no adequate attention. Marianini, Matteucci, Marshall Hall, Dubois-Reymond, Becquerel, and Brown-Sequard have in vivisections severed the spines and otherwise mutilated the bodies of a thousand animals, and thus fairly established this mysterious, but as yet scarcely comprehended *fact*. Let practical men and lovers of science observe and study this *law of electro-reflex action.*

But again: it has been observed that when actual death has been produced by a bolt of lightning, the excitability of the nerves by the electric current entirely ceases; yet it is often found that in these same cases the excitability of the *muscle fibre* remains. M. Matteucci remarks that no poison can diminish the excitability of the nerve trunks and branches like *hydrocyanic acid* and the *curara poison;* yet in these cases the muscular fibres retain their irritability to the immediate application of electricity. This will now and then be observed, as the author has certainly experienced in his practice, in certain cases of paralysis; i. e., where the large nerve trunks give no response to any kind of electric current that is brought to bear upon them, while at the same time the depending muscle groups supplied by that nerve readily contract, and where there is also a given *sensation* response to the direct application of strong currents of induction.

Alexander von Humboldt was the first to attempt to show, as he then thought he could produce by the voltaic current, contractions in a piece of fresh-cut muscle, deprived as much as possible of its nerve filaments. Müller, and Matteucci, and others followed up his researches here, until they, too, concluded that this kind of contraction can take place at the instant when the current commences to pervade the muscle, and at the moment when it ceases to circulate in it; and this whatever be the direction of the current relative to the course of the muscular fibre. They concluded, therefore, that the electric current alone, of all the agents tried, when it is applied directly to the naked muscle by the polarizing and more completely arranging and compacting the muscle molecules, is able, in the aggregate, to result in the shortening or contracting, *even without the intervention of the nerves.* But we must also bear in mind how difficult it would be to *exactly* obliterate all nerve filaments of matter from the mass of muscle, while the resulting effects of the current under the given circumstances may be unquestionably correct.

But we have ascertained that the nerves do possess in themselves a certain electrical state. We know, moreover, that this

electric state is modified by every kind of excitation there is produced through the nerves. We know that the muscles have likewise a natural electric state, which, too, is modified every time there is a contraction. Now, in the absence of excitation in the nerve and of contraction in the muscle, there must be a certain equilibrium, *which consists* in the circulation of native internal electric currents, together with the minute chemical processes there going on, the first and controlling cause of which is, the *vital force*. This gives to all organic molecules, which are naturally bi-polar, the arrangement necessary to the establishment of these natural nerve and muscle currents; but when once established, they are probably reciprocally sustained, that is, self-sustained by the said chemical action, that is as every where present in the body as life itself, accompanies vitality, and which it perhaps, in part at least, again of itself determines.

Thus is life transmitted by the nerves through means of their nervo-electric state, as found in their normal or healthy condition of vitality; and from this there results, in all the muscles and tissues of the living human organism, an analogous electric state and process, but with certain differences, due, as we have shown, to the different nature or function of these divisions of the living body. When the natural electric state of a nerve is modified by any cause whatever, the equilibrium is destroyed, and there results some sort of sensation or contraction, or, more usually, both. When this arises from the nervous centre, it appears that the polarization of the telegraphing nerve then on duty is brought about longitudinally; i. e., from one extremity to the other, just as is every conducting body that is traversed by an electric current, in such a manner that the negative pole of the molecules is turned towards the centre, while the positive is towards the muscles. This is just what would result from the action of a galvanic current travelling in the direction of the nervous ramification; i. e., from the head towards the muscles. This it is that explains why an electric current run in this direction, favors the contraction more than when run in the opposite direction. Then, again, if the influence exerted upon the nerve, instead of coming from the brain, rather comes from the mus-

cles, the polarization of the nerve must take place in the opposite direction; so that the positive poles of all the molecules are turned towards the nerve centres, while the negative poles are towards the muscles from whence the excitation came. Hence a galvanic current run *towards* the brain produces more *sensation*, but, when down-running, — i. e., *from* the brain, — more *contraction*. Polarization is therefore established in a contrary direction in a nerve of motion and in a nerve of sensation. The exception is where a compound nerve is tested with an electric current, or any way acted upon *in its course*, or in some part of its length; as, in that case, it may transmit motion towards the periphery, and sensation towards the brain, simultaneously, — its two portions being polarized in directions contrary to each other.

It has always been sought for as most important to be known, how the nerves terminate in the muscles, as well as in the other tissues they ramify. Dr. Waller has recently succeeded in following the course of the nerves to their ultimate ramifications with the greatest precision. He concludes that they are seen to penetrate even into the *interior* of the muscular fibres, with which they intersect *by loops* in such a way *that each elementary fibril of nerve abuts upon an elementary muscle fibre*. If this, beyond disputation, is uniformly so, it is no way wonderful that, where the nerve is polarized by any cause, it should bring about the simultaneous polarization of the fibre which it abuts. If the nerve is tetanized, the muscle fibre is tetanized also. If there is sensation, the normal state is disturbed, which polarizes the nerve, and acts upon the brain. It is but reason that every cause which alters the capability of the molecular

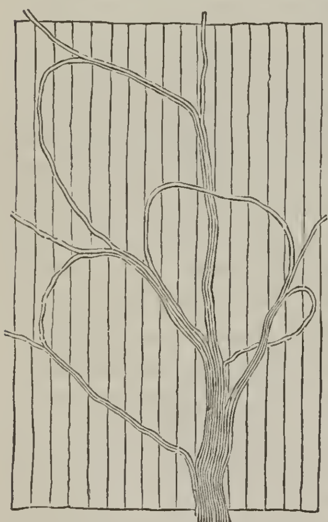


Fig. 51. A view of Straight Muscle Fibres, showing how the Nerves called Motor Fibrils terminate in and supply them, all being very highly magnified.

contraction of the nerve, prevents its polarity from being established, and consequently arrests the transmission of motion or of sensation, or of both, as seen in some paralysis. It is eminently probable, says M. De la Rive, that during all muscular contractions, as well as during the transmission of sensations, the nerve and the muscle are brought into operation at the very extremity of the nerve, and not all along its course.

Electricity in the animal frame is, hence, *the force* by means of which all nervous action is exerted, — not created at the moment when the nerve acts, but preëxisting in the particles of all organic matter. While under the absolute influence of vitality or life, these particles are arranged in a special, methodical manner, so that life cannot be considered as a *consequence* of the electric nature and arrangement of these molecules; but *life* must, on the contrary, be regarded *as the cause of their mode of grouping*, and consequently, indirectly, of the phenomena that result. Let life but be taken away, the particles still preserving their electric polarity and property, — i. e., their simple polarity, — and they are found grouped now quite differently. Here, they simply obey the forces of equilibrium that are proper to them, and present nothing but the ordinary phenomena of inorganic matter. Such is a dead body.

According to M. Matteucci and Alfred Smee, the *cause* of natural currents of animal electricity *is to be attributed to the chemical action that is peculiar to living organisms*, where arterial blood is in contact with the tissues, and consequently in the living voltaic arrangement for the life, nutrition, and repair of all the tissues, &c.; while Dubois-Reymond and De la Rive teach that these are *subordinate to* an undefinable *vital force*, and that the nerves in man are endowed with native *nervo-electric currents*.

We find, as is well known, that if we take a frog, and place a small bit of the *curara* poison, as by vaccination, just under the skin, the frog is soon killed. If, now, we electrize the large nerve trunks, we find they are dead; but if we touch the *muscles* with one of the electrodes, and that even with the weakest currents, they twitch most violently; and this lasts longer than

when the animal is killed by other means. Claude Bernard is far from believing, however, that this is evidence of the independent irritability of the muscles; but, rather, refers the phenomenon to such as where the nerves die in direction from the centre to the periphery, as evidently occurs in some central palsies, and also where there is death from chloroform. This, however, is questioned. Yet we can easily perceive that in any case where there is this partial effect or *state*, we shall find the electrization of the muscle substance to produce more decided effect than can be produced even from the exact nerve *border point*.

But it must be foreseen that the simple local excitement of the muscles by electric treatments, or by any other means, will never subject them again to the dominion of the will, so long as the nerve conductors from the central organs to the periphery are *un-toned*, and unless they are quickened by some natural, or adequate artificial action. To this end, Duchenne's method sometimes fails. Operating through the exact muscle border points, even, is not always a sufficiently sure exercise of the large nerve trunks. My custom is, therefore, in examining *such cases*, not to omit tracing from place to place the course of the largest nerves upon which the diseased part depends.

At a meeting of the Academy of Sciences, in Paris, M. Arago read the following notes from the illustrious Baron Humboldt, relative to muscular action and animal electricity: —

"Neither the jeers of certain editors on German credulity, nor the negative results obtained by two of our first natural philosophers, have changed my convictions regarding the influence of muscular action on the movement and direction of the galvanic needle. We have recently repeated our experiments at M. Dubois-Reymond's, and I invited M. Mitscherlich to attend, knowing his great dexterity in the management of delicate instruments. On giving tension to the muscles of the left arm, the needle was instantly made to move by M. Mitscherlich, and that in the direction predicted by M. Reymond, namely, indicating a current from the hand to the shoulder of the arm which was in action. On stiffening his right arm, M. Mitscherlich found that the needle moved in an opposite direction, and

traversed a smaller number of degrees; this arises from the fact that the energy of muscular contraction is not, under all circumstances, the same in both arms. Occupied, as I have been, for more than half a century, with physiological researches of this kind, the discovery of M. Reymond has most deeply interested me. It is a vital phenomenon, rendered sensible to us by an instrument of physics.

In connection with the same subject I may mention the result of some curious experiments recently made by M. Ducros. The conductors of a galvanometer were applied, one to the forehead and the other to the neck. The needle of it remained steady, and marked forty degrees. The patient's thigh was now strongly pinched, and under the influence of the pain, the needle passed to eighty degrees, with great rapidity. This experiment, frequently repeated, gave the same results; and M. Ducros hence concludes, "that all causes which increase vital activity, react on the galvanic needle, even at a distance from the point of their immediate action."

Laws and General Principles deduced from the Physiological Effects of Electricity.

Long before the experiments of Dr. Galvani, it was known, as we have shown, that electricity exercised a special action over organized bodies, as friction electricity, produced by the cylinder machine, had long been employed for medical purposes. But the *modus operandi* of that action was less known then than now. If we but carefully follow the delicate researches of M. Marianini, the Italian philosopher, we shall behold a very miniature creation, — the halo and glory of colors, the source of the beautiful flowers. If we observe the enormous labors of Becquerel, Matteucci, Arago, Gay-Lussac, and De la Rive, on fermentation, germination, and cell-growth, or on circulation, heat, and other chemico-physiological and electro-physiological phenomena, that mutually occupy the jurisdiction of organic chemistry and electricity, we then find tangible evidence and definite results, of the greatest magnitude and value.

Let us then, at least, take a glimpse at the influencing and often controlling power of electricity, as it relates to animal organization, by observing isolated facts, that are indirect as well as direct. Gay-Lussac succeeded in bringing about fermentation in the *pure* juice of the grape, which had been preserved, by protection from the air, in carefully sealed jars; which he did simply by means of platinum points, projecting within the jar for that purpose, and so conducting a galvanic current through the contained juice. From this it is proved that oxygen, from the electrolytic action, was actually developed at the poles within the air-tight jar, and thus became the cause of the fermentation, which it is known cannot take place where there is no oxygen.

The coagulation of albumen about the negative pole of an active current, observed by M. Lasaigne, is also the result of the presence, *at* this electrode, of acid, arising from the decomposition of certain salts. M. Becquerel observed repeatedly, that, while oxygen facilitates germination about the positive pole, it also frequently occurred that the acid, which is also liberated at this electrode, produces the contrary effects. In such a case, it is noticed that the seed grows best at the negative pole, where an alkaline base is accumulating. It is now evident, that the electric current acts alike upon vegetable and animal matter as electrolytes, and that it must necessarily bring about, sooner or later, a change in the organized body that is so subjected to the proper current.

Alexander von Humboldt, in order to test accurately the physiological effects of *immediate* galvanism, says he caused a blister, of the size of a crown dollar, to be placed on each of his own shoulders. They occupied the upper and outer portion of the deltoid muscles. When those two blisters were opened, he says there trickled down his back the ordinary clear serum, which dried on the skin, showing nothing but a delicate gloss from the contained lymph, and which was readily washed off with simple water. The right blister was first experimented upon, by placing over it, in immediate contact with the raw place, a small plate of silver, that mostly covered this denuded

blister; but there was neither felt nor seen any effect until the similar application of a plate of zinc over the other blister and metallic contact was made between them; when, at each contact, there was a heavy, dull sensation of burning. This sensation, he says, sensibly increased from half minute to half minute. But what was most surprising to all present was, the *appearance* of the now flowing secretion from the blisters; it was not transparent, nor was it bland, as before, but in the course of a very short time, it had become reddish, producing evidence of irritation of the skin wherever it flowed over, leaving there reddish stripes. No angry wound could produce such acrid liquid and quick-made excoriations. The gentleman who aided in these trials repeated the effects by reversing the arrangement of the silver to the left shoulder. In four minutes, violent inflammation set in, with increased local redness, together with the excoriations of purple and red stripes, produced down the back by the moisture that flowed from under the metal plates that were thus on the raw surfaces. When the experiment was ended, says Humboldt, notwithstanding all the care taken to gently wash away the flowing moisture as well as could be, still did his back appear like a whipped criminal. This very remarkable experiment, for testing the physiological action of that method of using galvanism, was given by Baron Humboldt, the Nestor of natural science, early in the year 1790, and even before the discovery of the voltaic pile, but after the discovery of the electro-muscular contractions by Galvani, through the twitchings of dead frogs from metallic contact, (see page 72;) a phenomenon, which it is well known led Galvani to suppose that the electric source, was no other than that which was native in the muscles and flesh, and that the nerves were only the conductors of the positive, or plus electricity that was accumulated in the deep parts; they only leading it to the negative or minus electricity which was on the surface. But Humboldt offered two explanations of this, also, that were satisfactory.

The electro-physiological phenomenon of "*closing and opening convulsions*" has always received the greatest attention, and many ideas have been advanced by philosophers to account

satisfactorily for them. M. De la Rive compares them to the deviations of the galvanometer, *under like circumstances*. For instance, while Faraday was making experiments to determine the velocity of galvanic electricity, he obtained the use of several hundred coils of large telegraph wire, covered with gutta percha, and intended for subterranean or submarine lines, which were half a mile in length each. He suspended these to a series of barges, in a canal, so that each coil was plunged entirely under water its whole length, with the exception of a very short bit at each end. These he connected metallically end to end, so as to constitute a single wire of some two hundred miles in length. Then he attached to one end of this long, insulated wire a compound galvanic battery composed of three hundred and sixty cups, and hence as many pairs of zinc and copper plates, in acidulated water, including in the circuit also a very sensitive galvanometer. Then, after the current had thus been traversing this long wire for a time, at the moment when communication was cut off between the battery and the long wire, *a very strong shock was felt*, by merely touching for an instant either end of the long wire. This he found could be repeated some forty times in succession, with the same result, but less and less in degree. Again: instead of thus touching the long wire and so leading off the accumulated electricity so immediately after taking away the battery from it, if one pole or end is placed in connection with the galvanometer, while the other end or pole connects with the ground, then the needle of the instrument was quickly and powerfully deflected; and this was still sensible, if the trial was not made again with it, for some half hour.

Faraday explains this as the result of the thus formed *unique* Leyden jar of enormous length; consisting of the long wire, the envelope by which it was insulated, and the liquid which surrounded it. The wire plays the inner coat of the Leyden jar, which is charged. The gutta percha, being a non-conductor, is the jar itself; while the water, or the moist earth, is the conductor for its negative electricity, like the outside of a positively charged Leyden jar. Volta early showed that a Leyden jar might be charged by connecting its inner coating of foil with

the electric pile of his, then in use. But what interests us particularly, says De la Rive, is the curious fact, that the instant the contact is *made* with the body, there is a shock; or if with the galvanometer, there is that instant forwarded a powerful *deflection;* which is again repeated, though in a less degree, at the moment of disconnecting the circuit;—provided, always, that the other end of the galvanometer and current is in connection with the earth. "*Here, then*," he observes, "*was a closing and opening convulsion*, much like that observed in the human organism." But we do not, we cannot conclude that they are alike.

Volta's *hypothetical* "counter-current" has been fairly disproved by Marianini, who most carefully investigated the whole subject of opening and closing convulsions. He showed that the contraction which takes place at the moment of the closing of the galvanic stream, and that which takes place at its opening or cessation, have not the same intensity; at least, this is more visible when the nerve has lost a portion of its excitability; and that one or other of the twitchings is the more powerful, according to the direction the electric stream is made to traverse the nerve in respect to its ramification. To illustrate this difference as he did, and at the same time to observe some other important physiological facts, we can have recourse to the prepared thighs of a frog, which will as well answer for this trial. Only let the thighs of a recently-killed frog be attached to the body, or to the lumbar vetebræ simply by the lumbar nerves. Into a cup of water plunge the feet and legs, while into another cup of water the lumbar portion of the pendulous nerves is caused to be immersed. When thus placed, plunge the positive electrode of a gentle current into the cup that contains the lumbar nerves, and all is prepared to observe the result. Now, if the negative electrode or pole of a battery is suddenly plunged into the cup of water that contains the feet, the muscles contract every time it is so done, which, of course, is at the closing of the circuit; but the contraction is not seen on withdrawing the pole, which, of course, opens the circuit; but on changing the place of the poles,—i. e., reversing them in the

cups, — the effects are found to be just the reverse. This trial proves, then, that the contraction or twitching is caused *at the closure of the down-running current*, which is *with* the ramification of the nerves; but *not at the opening*, or discontinuing of the up-running stream, i. e., in an opposite or *inverse* direction to the branching out or ramification of the nerves.

Another arrangement of the prepared frog thighs, made by Marianini, proves the same facts, and renders these fundamental results familiar; and for that reason they are repeatedly shown in this work. The frog is to be prepared as before in Galvani's original method, but arranged now so that one leg shall be placed in each of the two glasses of water. If, then, the poles of a moderate current are quickly plunged into the water of the respective cups, the legs, if from a recently-killed frog, will spring out of the cup; but if now we forcibly retain them in the cups, and then frequently repeat the closure and opening of the circuit, we shall for a while see twitchings in both legs, and that as well on opening as at closing the circuit. Then, by continuing to operate thus for a time, the excitability diminishes or exhausts, until we notice that only one of the limbs contract, and that when the current is *closed;* and this is the limb with the negative pole, and where, of course, the current runs down it. But if the poles are plunged into the water and retained there for a little time, then, on removing them, or one of them, the twitching is seen to take place in the opposite limb, i. e., in that one that is traversed by the current running up it. If the trial is reversed, by exchanging the poles in the cups, and thus causing the current to run up the limb where it had before run down, and *vice versa*, the result will follow in accordance with the same law, viz., the closing contraction will now be in the limb where before was the opening.

Further: if the thighs of two frogs are now prepared, as before described, and the four large nerves are placed in the same glass of water with them, while the flesh of the two legs of the one frog is transfixed by the positive electrode, and the flesh of the two legs of the other frog is similarly arranged with the negative pole then the frog that is at the negative, and

traversed with the direct or down-running current, is seen to tremble at the closure of the current, whilst at the opening of the same the trembling is seen in the other frog legs, where is the positive pole, and the current is traversing indirectly, or up-running. This trembling in the one experiment, and the twitching in the other experiment, arise, as we see, under opposite directions of the current.

Marianini further observed, that when electricity acts immediately over and upon a muscle, contraction takes place *only* at the instant when the current is closed, whatever be the direction of the stream. He therefore termed this mode of action the *idiopathic*, to distinguish it from the action produced by applying the electrodes over the nerve trunk of that muscle which he termed *symptomatic*. By thus operating on a live frog, whose posterior limbs remained attached to the living animal *only* by the two carefully exposed nerves, (sometimes termed lumbar, sciatic, ischiatic, or crural nerves,) and placing the hind legs in contact with one pole of the battery, while one or both of the fore legs are in contact with the other pole, as by placing them respectively in little shallow vessels of water,—if now the stream traverses the hind legs *directly*, or down-running, the frog will agitate those posterior limbs *at the moment when the current is closed*. But then, at the moment when the current is *opened*, the frog utters a prolonged cry with the full force of its lungs, as from pain, and at the same time raises itself with rigid contortions on its fore legs or arms, without the least agitation of the posterior legs. Then, after a considerable rest, if the current is reversed so as to enter the hind legs by the feet, and hence in an inverse direction, it is now, when the current of electricity is *closed*, that the frog utters its cry, accompanied with contortions, &c., and it repeats the cry if the circuit is left a little longer closed; but when opened, the posterior extremities are agitated again, and the animal ceases to cry or show contortions.

By this we see that the contractions take place only at the closing or making of the circuit, and not at its opening, if the current or stream is direct, or down-running; and only appear-

ing at its opening or discontinuance, and not at its closure, if the current is the inverse or up-running, i. e., towards the spinal marrow and brain.

M. Nobili distinguishes from such trials, as he thinks, some five stages or degrees of irritability that may be found in the same set of nerves in the same animal. The *first stage* is where the contraction appears in four conditions, as both with the *up-running* and *down-running* currents, and at the *closing* and *opening* of the circuit. The *second stage* is where one of these is wanting; i. e., where there is no contraction from the closure of the up-running current. The *third* is where two of these are wanting; i. e., where also the contraction is wanting at the opening of the down-running stream. The *fourth* is where but one contraction remains, and that is at the closure of the direct or down-running current. The *fifth* is where there is no sort of contraction in any case, either at closure or opening of the circuit, nor at the up or down traversing current. We can state it, in short, thus: —

1. Contraction at closure and opening of both up and down currents.
2. Contraction lost at closure of the inverse current.
3. Contraction lost at opening of the direct current.
4. Contraction lost at all but at closure of the direct.
5. Contraction lost at all and under all circumstances.

By means of a proper current of galvanism, and under this *rule*, he thinks that we may be enabled to judge of the state of irritability of any nerve trunk; indeed, that this becomes a kind of by-law for the operator, not only for judging of new cases, but also in determining the advance or retrograde effects of the electro-medical treatments. But we must bear in mind the actual difference there is between irritability and capability: the former admonishes us to be careful, the latter is the cure.

We do not usually observe any sensible contraction of muscles when under the *steady* running of a *feeble* current of galvanism. But this, as say Remak, De la Rive, and others, does not prove that there is not a certain effect being produced on the nerves by the steady and gentle inworking of this current.

Indeed, here, according to my experience, is one of the most marvellous and valuable effects of all the medical uses of electricity. Even as long ago as in Volta's day, it was known that the prolonged action of a steady current in the same direction, — say for an hour or so, — on the nerves of a mutilated frog rendered them so that contractions were no longer produced, either at the making or breaking of that current. But the instant it was exposed even to the same current *reversed* in direction, the frog showed very violent contractions and agitations, even stronger than at first.

Therefore, the continuous action of any moderate galvanic current, we may then safely conclude, *does not* produce any sort of disorganization of the nerve, as has been so frequently taught, but that it rather *modifies* it, to a certain degree, so that it obtains *a new susceptibility*. If the nerve is sick or diminished in its physiological irritability and power, this current can increase and restore that; if the nerve is already alive and in health, it can thus be exalted above the normal. When, by a protracted duration of the same even directed stream, the nerve gets accustomed to this new state, it may remain so for a considerably shorter or longer time, even after the cause that has produced this changed state is removed. For we notice that, if we suspend the action of such current for a few moments, and then apply it again in the same direction, we find it produces no sort of effect, because it finds the nerve in the same condition still which that current tended to produce on it. It is no longer the same, however, if now the direction of the current is changed; for the more the nerve has become accustomed to the first current direction, within certain bounds, all the less will it tolerate the action of the second, or reversed. But what this exact modification is, we can only infer. It clearly proves, that the modification produced by each direct and inverse current, and by each closing and opening current, is, in fact and effect, very different. Therefore M. Nobili calls the first *direct alteration*, which we understand is produced by the direct or down-running current, while the second he terms the *inverse alteration*, which is likewise produced by the inverse or up-running current.

But all these results, obtained so uniformly by experiments on dead or mutilated animals, we find to *vary*, considerably, when tried on *living human beings*. The phenomenon is greatly varied with the strength, and way, the current is brought to bear upon the individual; and besides there are wide differences in persons as to less or greater nerve excitability. Relatively speaking, then, we can say, that the more powerful currents show their effects most at the instant of opening the circuit, and that the reverse is true when employing a more feeble battery current. This must be due to the greater degree of the modification brought about by the recent running current through the nerves. M. Nobili believes that his *law of contraction* is not affected, if we include also the muscle with the nerve, i. e., if one electrode is over a nerve, while the other is upon the muscle that is supplied by it. But he thinks the effect is no longer the same, if the current is directed so as to traverse only the muscle fibres; for in that case, the twitch takes place only when the circuit is closed, and that regardless of the direction of the current. But we do not observe now the contraction that was otherwise produced at the opening of the circuit, and hence called the opening convulsion. This last phenomenon, when produced, is no doubt the result of the modification produced in the nerve trunk while it was being traversed by the previous somewhat strong current, as we have before shown.

Dr. Volta early made trials in the ordinary manner with the recently-killed frog. He placed the legs, when properly prepared, astride of two glasses of water, so that one foot should be in each of the glasses. He then brought the current of a moderate pile to pass steadily through these legs, up one and down the other, by placing the electrodes respectively in the two glasses of water. This he would maintain for a half hour, when the legs would no longer twitch, either while he made or broke the circuit. But on exchanging the poles, so that the current passed now in the opposite direction, then neither closing nor opening of the circuit could be done, without the contraction being repeated strongly at each time. If the exchange was then again made, and in like manner continued for a half hour, at

the end of which time, as before, there could be produced no contractions; but this power was regained afresh, as before, upon the simple reversing the direction of the current, and then opening and closing the circuit. By such means he produced changes from half hour to half hour, and even more frequently, and was able, for an entire day or longer, first to annihilate and then to restore at pleasure the natural excitability of the nerves and muscles of a mutilated animal. This is the origin of the term "*voltaic alternatives*." The results of the alternate use of galvanic currents we shall learn to be of the greatest importance in the details of electro-medical practice. The new condition worked up by the current in a given direction, and still more manifested by given careful and definite variations, we may understand to be a condition which, from analogy with what takes place in all other cases, must be *a polarization of the molecules of the nerves*, alternating with the molecular discharges. So long, he says, as the nerve has sufficient vitality, and hence irritability, left, it reacts just as soon as the current ceases; i. e., it resumes its natural molecular state; but if the animal is mutilated, killed, or abused by the experiments of repeated currents, there is soon obtained a *toning down*, or rather, probably, an exhausting of the nerve resources, which is shown, by this reaction no longer taking place; therefore a current of electricity given in the opposite direction is necessary to restore that state. I will only add here the fundamental and instructive *law* laid down by M. Dubois-Reymond: "The motor nerves are not excited so much by the absolute degree of the density of the current of electricity, as by the *variations* that occur in the sum of this density,—from one instant to another; the excitement from these changes being greater in proportion as they take place more rapidly, or as they are more considerable in a given time."

Electricity, therefore, acts upon the animal body, both in health and disease, in a manner that all scientific observers acknowledge to be peculiar to itself, and producing results otherwise unattainable. Dr. Galvani, as we know, was the first to produce muscular contractions by the aid of galvanic electricity.

His first trials in this line, let me repeat, were upon the frog. He cut the frog across in the middle, and then after quickly opening its body, the points of the scissors were passed beneath the two visible lumbar nerves, which are plainly seen lying superficially upon the psoas muscles, as the frog lies opened and upon its back, like two white threads. It is well, in preparing the frog for this experiment, to remove two or three of the lower vertebræ, and thus the lumbar nerves are left alone as the only connection between the thighs of the hind legs and the upper vertebræ of the body. If, now, this portion of the frog is quickly and adroitly placed, say suspended to an insulated electrode of a feeble battery by the cut tips of those large nerves, and then the leg muscles are touched by the other insulated electrode,— not insulated from the frog, but from every thing else,— so that a gentle current passes from the nerve to the muscle group of the leg so touched, or to both legs if both are so touched simultaneously, then the limb or limbs are seen to contract with an extremely sudden and strong twitch. If this trial is made by placing the legs of the frog each in a separate glass of water, and then plunging the electrodes into the water of each, that instant the frog's legs undergo so sudden and violent a contraction, that they are often thrown entirely out of the glasses. It is not necessary to include the whole nerve and muscle in the current to produce this effect; for it is found that a very short portion is sufficient, and that the nearer the upper portion, the greater the effect from the same current.

It is said that in 1818, Dr. Ure made some capital trials with electricity on the body of a man who had been hanged, immediately after the execution. He expeditiously submitted the fresh body to the action of a galvanic current from two hundred and seventy series of copper and zinc pairs of sixteen square inches of surface each. To reach directly the larger nerve trunks of the but recently dead body, he made incisions into the flesh, so as to place one electrode in actual contact with the spinal marrow, while the other was in immediate contact with the great sciatic nerve. By now closing the circuit, all the limbs of the body were agitated by convulsive movements. Then, again

taking the electrode that was on the sciatic nerve, and placing it farther down, at the heel or ankle, the knee having been previously bent, the leg was extended with such violence that it very nearly overthrew one of the assistants, who endeavored in vain to prevent the extension. He also produced contractions of the diaphragm, which caused an artificial respiration.

Thus, in the early part of this century, the bodies of a very great number of criminals were subjected to a wide variety of experiments, by Ritter, Rossi, Wassali, Julio, Matteucci, and Wilson Philip. The former, indeed, thought he had discovered that electricity of the positive pole increases vitality, whilst that of the negative pole diminishes the vital forces; and that the former swells the muscles and fortifies the pulse, while the latter relaxes the muscles and reduces the pulse. He also fancied he found a difference in the action upon the organs of sense. Dr. Philip, by dividing the eighth pair of nerves in living animals, believed that he might substitute the artificial electric current of galvanism for the natural nervous force, as in digestion, secretion, &c.; while others advanced the idea plainly that nervous force is simply and only an action analogous to that of voltaic electricity, independent of vital force, — in fact, *as constituting vitality itself.*

But all these were evidently hasty conclusions from mere semblances, or from false premises, to which the author only alludes because still quoted as if true. We will therefore leave aside, as much as possible, all speculations and *curious* researches whose results are now contested, to occupy ourselves in a more precise and scientific manner, consulting only those physicians and philosophers *who have been especially engaged with this particular branch of research.* Most of all do we wish to learn the real actions of the different electric currents, and the various modes of employing those currents upon the different parts of the living human organism, and to confine ourselves mainly to stating, as concisely as can be to be clear, the positive facts that the now multiplied experiences by competent men in actual clinical practice, have thus placed beyond all kind of doubt.

Inasmuch, therefore, as physiological action may be consid-

ered as a *source* of electricity, as says De la Rive, as well as *influenced by* electricity, we may be able all the better to rightly estimate that share of influence in the phenomena that are brought about by the applications of electric currents or shocks, when we also comprehend the work of the natural electric currents which the human organism possesses, and which are inseparably connected with its healthy functions, as well as its abnormal states, and actions.

Effects of Heat and Cold on the Nervo-Electric Batteries.— It is no uncommon thing to have the working of a set of compound galvanic batteries diminish as much as one half by sudden cold weather, or increase one half *in effects of working* by a change to very warm air. For this we must be prepared. And of all agents which act upon the human frame, *variations in temperature*, if sudden and considerable, doubtless produce the most potent results. It is demonstrated that the functions of animal life are actually voltaic-like; and it is possible that this view of the exhausting effects of extreme heat, and of the suspension of action from extreme cold, accounts for these familiar facts. Indeed, from actual experiment it is shown that the phenomenon of life is depending upon unceasing native electric currents, and that these are enormously influenced by heat and cold.

Heat first excites; then, if intense or prolonged, it exhausts the powers of the part or whole of the animal on which it acts. Cold first increases respiration, but a greater degree depresses, then, at last, even to total inaction; so that there is not only cessation of feeling and of motion, but even of life itself. Variations in temperature act more powerfully than we are apt to think upon the whole electro-nervous apparatus of our organism, and hence affect the cerebro-spinal axis. Thus heat and cold affect pains, delirium, sleep, inflammations, and all those conditions and diseases in which the electro-nervous power is mainly concerned. In nervous restlessness or sleeplessness, if cold water is applied over the top of the head, or sponged over the whole body, until some little chilliness is produced, a good sleep will often follow, even where all nervines and narcotics have failed.

Heat is constantly generated by the ceaseless *vitalized* electro-chemical actions taking place in the peripheral battery of the animal organism. In fact, it appears demonstrated that the body is warmed by the changes that are ever taking place all over it; and the changed matter that is the product of this, is simply *eliminated* by the lungs, kidneys, and other organs.

Sir Edward Holmes showed, long since, that if the nerves of a stag's antlers are cut across, the heat in the antlers is increased. When the spinal marrow is divided, we find the heat of the parts, from which the nervous supply is cut off, almost invariably rises, at least for a given time, to several degrees above the temperature of the inner part of the mouth. The peripheral battery, in health, is evidently kept in due subjection by the central battery; and if the two are by any means severed in any part of the body, the action beyond that spot appears to run wild and uncontrolled, until it runs down to fatty degeneration, atrophy, or to palsy, and then to death. All this is familiar to physicians who see the various cases of *early* traumatic paralysis. But after the abnormal heat, the muscles rapidly waste away, and then there is deficient heat. Also, as part of the phenomena, we observe large quantities of animal matter in the urine, showing that no small *change of matter* is taking place. Indeed, this abnormal rapid work and extensive change of matter appears to be precisely similar to that observed in an ordinary galvanic battery, where there happens to be no resisting medium to the pairs in each cell, but the action is, as Faraday would say, "*immediate*," *local*, self-devouring. Besides, may not *this phenomenon*, when circumscribed in effect, constitute what we call local *inflammation?* and, when general, constitute *fever?* Compound galvanic batteries can be variously *modified* in their "immediate action" by unbalancing their materials.

Osmotic Force. — What is termed "*osmotic force*" is quite different from ordinary endosmose. Napier succeeded, simply by aid of the current of a single pair of zinc and copper, which were plunged respectively into *two* compartments of a vessel, separated only by a porous diaphragm, each filled with distilled water, in thus making a volume of water of about two pounds'

weight, to pass from the positive into the negative compartment by the end of forty days. Wiedeman, by a series of trials in accurate research, succeeded in discovering the law of this phenomenon, and that is, "liquids, when traversed by an electric current, have a very decided tendency to move or flow *from the positive pole to the negative pole*, provided there is a certain *resistance* to the passage of the electric current." It is well for us to observe that here are found two facts that interest *us*, and these are — the quantity that is thus transported through a spongy mass in a given time is just in proportion to the intensity of the current employed. This doubtless holds good *as a law in physics;* but in relation to the current's action on living saturated tissues in the human organism, we conclude the proposition must be somewhat modified. But Wiedeman thought to have determined that the quantity of liquid transported by the power of a voltaic current through a porous partition, as the pipe-clay cup in a Daniell battery, is independent of the extent or thickness of this partition. But M. De la Rive modifies this by summing up the whole law thus: "The force with which a galvanic current tends to transport a liquid through a porous partition, from the positive to the negative pole, is measured by a pressure which is directly proportional to the intensity of the current, to the electric resistance of the liquid, to the thickness of the porous partition, and *inversely* proportional to the *surface* of that partition." Now, as in the decomposition of acidulated water, one equivalent of sulphuric acid goes with the oxygen to the positive pole, while an equivalent of hydrogen is liberated at the negative pole, so the question arises, whether the water thus under the influence of an electric current, and becoming molecularly polarized, does not actually present *a circumstantial electrolytic phenomenon.*

Electrolysis and Catalysis. — The *law* of electrolysis is this: that a similar quantity, as, for instance, one equivalent of electricity, always decomposes one equivalent of an electrolyte. The *law is general*, when the combination that is submitted, is composed of only two equivalents, but is *modified*, in cases where more than one, — and particularly so, where vitalized compounds are the subject of trial. This *law* is frequently

masked by a crowd of circumstances that arise in electro-therapeutics. But if we set out with the idea, laid down in the outset by Faraday, that the electric current, which acts in electrolysis, is only the chemical, *transported*, or put into process of transportation from one particle or point to another, under the form of a current *acting at a distance* instead of acting only at the contact, then the *law* of electro-chemical equivalents is a necessary and rigorous consequence of this; for the same chemical force must decompose every where an equivalent of the compound body.

We may, therefore, conclude that *the law of electro-chemical equivalents is found to be justified within the limits of error of observation*, and that if there is a portion of electricity that traverses the liquid without producing appreciable decomposition, it can be only a very small fraction of the total quantity of electricity transmitted. But if the liquid acted upon is in living tissues, then this effect is somewhat modified, provided, also, the current is moderate, for there may not be so much electrolysis as catalysis; i. e., there is doubtless here more of the work of *composition* than of decomposition.

The influence that naturally determines sensation and muscular contraction in the normal state, is now termed the "*nervous force*." Formerly this was termed the *nervous fluid;* but this arose from an hypothesis, which, in truth, has nothing to justify it; but the *will* or *volition* is, before and above all, the great moving *cause* that in the normal state is capable of developing in nerves the nervous force, which transmits, or rather propagates, itself to the muscle, producing in them contraction and motion. Next to the controlling power of the will over the motor nerves is the action of electricity; then mechanical action, chemical action, heat and cold. But in its mode of action, electricity differs from all the other exterior agents in characteristics that are alone and peculiar to itself. Its great relative importance here is seen by its effects approximating so nearly to those which the will calls into action, and which natural effects we believe we are able to restore again to the dominion of the will, *under certain circumstances*, even when it has been in effect apparently totally lost.

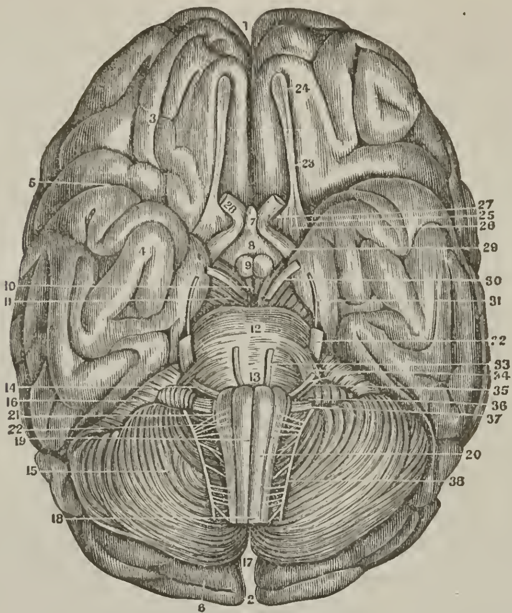


Fig. 52. A View of the Brain, showing its Base together with the Cerebellum, and their Nerves.

1. Anterior Extremity of the Fissure of the Brain Hemispheres.
2. Posterior Extremity of the same Fissure.
3. The Anterior Lobes of the Cerebrum.
4. Its Middle Lobe.
5. The Fissure of Sylvius.
6. The Posterior Lobe of the Cerebrum.
7. The Point of the Infundibulum.
8. Its Body.
9. The Corpora Albieantia.
10. Cineritious Matter.
11. The Crura Cerebri.
12. The Pons Varolii.
13. The Top of the Medulla Oblongata.
14. Posterior Prolongation of the Pons Varolii.
15. Middle of the Cerebellum.
16. Anterior part of the Cerebellum.
17. Its posterior Part, and the Fissure of its Hemispheres.
18. Superior Part of the Medulla Spinalis.
19. Middle Fissure of the Medulla Oblongata.
20. Corpus Pyramidale.
21. Corpus Restiforme.
22. Corpus Olivare.
23. The Olfaetory Nerve.
24. Its Bulb.
25. Its External Root.
26. Its Middle Root.
27. Its Internal Root.
28. The Optie Nerve beyond the Chiasm.
29. The Optic Nerve before the Chiasm.
30. The Motor Oculi, or Third Pair of Nerves.
31. The Pathetic, or Fourth Pair of Nerves.
32. The Trigeminus, or Fifth Pair of Nerves.
33. The Motor Externus, or Sixth Pair of Nerves.
34. The Facial Nerve.
35. The Auditory Nerve, — the two making the Portio Dura, or Seventh Pair of Nerves.

36, 37, 38. The Eighth Pair of Nerves (The Ninth Pair are not here seen.)

Effects of Electric Currents on the Brain.

Dr. Matteucci has made direct experiments to discover the effects of the continuous current of galvanism when applied *immediately* to the uncovered brain.* For this purpose he employed a good tension current from a compound battery of some sixty pairs. When the poles were applied fairly to the respective hemispheres, he observed that the animal did not start; nor was there any visible effect when the cerebellum was touched. But as soon as the electrodes were directed to the *tubercula quadrigemina* and the *crura cerebri*, while the current was passing, the animal began to scream, and simultaneously all the muscles of the body and limbs were contracted and agitated. As soon as the current was removed, this phenomenon ceased also. Such are the naked facts, with a constant current. But it would be exceedingly interesting to pursue this subject by experimental research, if it could only be instituted without the objection of solution of continuity of such vital parts. True, Professor Weber has made some interesting investigations into the action of induction currents when applied directly to the brain of living animals, which, of course, are mutilated. But he found no marked effects, even when the sharp electrodes were thrust *into* any part of the great medullary substance. But as soon as this current was directed through the *tubercula quadrigemina*, then irregular convulsions are produced, which, he says, very much resemble clonic cramps, and such as are noticed in those patients who are suffering with certain existing disease of the brain. These movements did not appear uniformly, nor yet irregularly, in any or all the muscles, but rather in certain groups of muscles which are naturally — or, as we could say, are physiologically — combined in action, as by reflex influences. If these kinds of currents are brought to bear upon the *medulla oblongata*, tetanic convulsions are the consequence, much like those observed in persons or animals when poisoned with strych-

* Traité des Phénomènes electro-physiologiques des Animaux, Paris, p. 242.

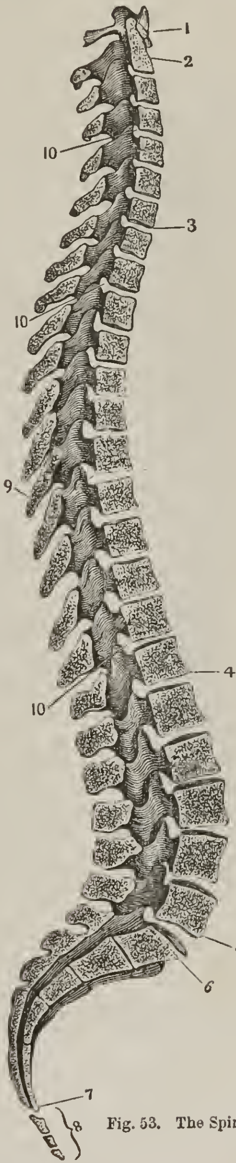
nine. The next phenomenon observed by Faradaizing the *medulla oblongata* was, the actual cessation of the heart's action. From these trials, Professor Weber thought we might yet find that, where clonic cramps are seen, there exists a disease of the brain; while, if tonic cramps are observed in a patient, there exists disease of the *medulla oblongata*, or spinal cord. But up to the present time, such conclusions are not entirely proved.

The Vital Spot. — At a meeting of the Academy of Sciences of Paris, M. Flourins took occasion to speak of the actual locality of the vital spot in the human organism, or *primum mobile* of the respiratory act. By several experiments, he has now determined that that spot is situated exactly at the point of the *calamus scriptorius*, between the ventricle of Aurentius and the junction of the V-shaped gray matter of the pyramids. This spot is, according to M. Flourins, about the size of a *pin's head.* Above or below the same, he found that a sharp-pointed instrument may be thrust in, without causing the respiratory movements to cease; but when this identical spot is transfixed, life ceases instantly. M. Flourins made this communication in order that the precise locality of the *nodus vitæ* should be well understood. (See pp. 158, 264, 589.)

May we not believe that the *superior central ganglia* (pineal gland) is the centre or *president* of the great ganglionic chain of nerves? Descartes long ago contended that it was "the seat of the soul." It is heart-shaped, and is centrally and securely situated in the middle of the base of the brain. It is evidently the *seat of life*, as vitality appears to reside peculiarly in the ganglionic nerves.* If this ganglia be disturbed by a probe in the living animal, the eyes roll; if more disturbed, the animal moans, bleats, or screams, as with pain; if compressed, the animal snores, and there is coma; if punctured with a fine needle, there are general spasms; if crushed, there is instant death. True, all the different kinds of nerves in the human organism are intimately connected together, and so we should study them; yet we must also know that their offices are classed in two great departments, viz., the *organic* and the *animal*. The brain is the centre or *president* of the animal nerves; and certain parts of the brain preside over mental and particular functions of animal life, (not phrenologically, but) as do the organic ganglia preside over the functions of the organs with which they are most directly connected; each ganglion in the chain of the latter having a special duty, peculiarly its own, assigned to it; or, in other words, *each organ has a special ganglion to preside over it.* (See pages 247, 264.) And these ganglia I believe to be the very nucleus of much "*reflex action.*"

* See a recent work by Dr. O'Reilly, of New York, on the Anatomy of the Placenta, &c.

The Spinal Column is illustrated by Fig. 53, which is a lateral view. Having been sawn down through its middle, it shows its natural curvatures and internal structure.

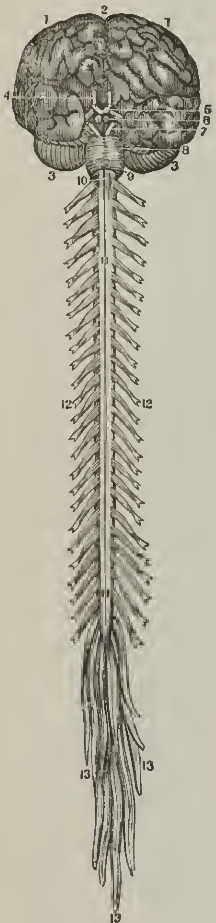


1. The Atlas.
2. The Dentata.
3. Seventh Cervical Vertebra.
4. Twelfth Dorsal Vertebra.
5. Fifth Lumbar Vertebra.
6. First Piece of Sacrum.
7. Last Piece of Sacrum.
8. Coccyx.
9. A Spinous Process.

10, 10. Intervertebral Foramina.

Fig. 53. The Spinal Column.

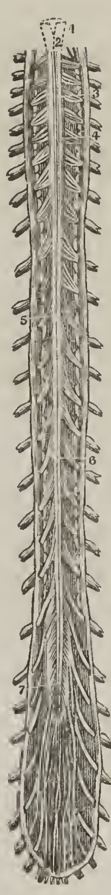
The Brain and Spinal Cord are shown in Fig. 54, which gives an anterior aspect of them, as extracted from their bony cavities.



1, 1. The Hemispheres of the Cerebrum.
2. The Great Middle Fissure.
3. The Cerebellum.
4. The Olfactory Nerves.
5. The Optic Nerves.
6. The Corpora Albicantia.
7. The Motor Oculi Nerves.
8. The Pons Varolii.
9. The fourth Pair of Nerves.
10. The lower Portion of the Medulla Oblongata.
11, 11. The Medulla Spinalis in its whole length.
12, 12. The Spinal Nerves.
13, 13. The *Cauda Equina.*

Fig. 54. The Brain and Spinal Cord.

The Spinal Cord is shown by Fig. 55 — a posterior view.



1. Inferior extremity of the Medulla Oblongata.
2. The Calamus Scriptorius.
3. The Posterior Face of the Spinal Cord, showing its Fissure.

4, 5, 6, 7. The Posterior Roots of the Cervical, Dorsal, Lumbar, and Sacral Nerves, uniting with the Anterior Roots to pierce and pass out of the Dura Mater of the Medulla Spinalis, just outside of which are seen the Ganglionic Enlargement. Under 1 can be seen the sub-Occipital Nerve Roots.

Fig. 55. The Spinal Cord.

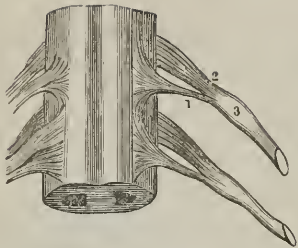


Fig. 56. A View of a Piece of the Spinal Cord at natural size; showing the origin of some Spinal Nerves.

1. Shows the Anterior or Motor Root of a Spinal Nerve, such as are given off from the Cord, between the vertebræ.
2. Shows the Posterior or Sensory Root of every such spinal nerve; which, together, make it a *compound nerve*.
3. The Ganglion that connects each of these with the Great Sympathetic by a short route.

Effects of Electric Currents on the Spinal Cord.

By the vivi-section of animals, Professor Weber has demonstrated, with the aid of electro-magnetism, that the spinal cord is the nervous centre of all the muscles of the trunk and extremities. If one of the electrodes of such a machine, with the current at maximum, be placed at the upper end of the exposed cord, while the other is directed to the lower end of the cord, we find that all the muscles of the body, or of the animal, are brought into violent tetanic convulsions. The same is true, if the electrodes are placed, the one to the anterior, and the other to the posterior roots of the upper portion of the spine, and even of the lower portion also, if it is yet intact.

Dr. Althaus justly says, if the spinal cord were simply the common trunk of all the motor nerves that emerge from the vertebral canal, then electrizing the lower part of the cord should produce a convulsion of the lower or hinder extremities, but not of all four extremities. If, however, the spinal cord is cut completely across transversely, and then only the lower half is Faradaized, the muscles of the lower or hinder extremities enter into contraction; and even if now both parts of the cord are made to touch each other closely at the transverse section, so that the simple passage of the electric current to the upper portion of the cord is easy, yet do the muscles of the upper extremities remain perfectly quiet. From this we may fairly infer, that the convulsions described are not produced simply because the electric current is *transmitted from* the cord *to* the motor nerves, but rather

because the passage of the electric current along the spine *excites the action proper of the spinal cord*, which in its turn excites the property and office of the motor nerves to bring about commotion of the muscles. This species of reflex action is often as clearly illustrated in patients, who present for examination with uncertain lesions of the spine. Whenever tetanic convulsions are produced in the extremities, *by thus immediately Faradaizing the cord*, they continue a little after the electrodes are removed; but if the anterior root, or even the whole mixed nerve trunk, is thus excited *at some little distance* from the spine, instead of applying it to the cord itself, the tetanic convulsions disappear the instant the circuit is opened.

Another fact: it has lately been observed by Dr. Baielacher, that if induction currents are applied to the large motor nerves of the hinder extremities of an animal, while the spinal cord is *at the same time* being traversed by a constant galvanic current, then commotions are produced in those muscles, the nerves of which are being traversed by the interrupted current.* Therefore he infers, that the diminution of excitability from the action of a continuous current is limited in the spinal cord, and hence does not extend to the motor nerves and their depending muscles.

Besides, if the whole spinal cord is caused to be traversed (i. e., lengthwise) by a strong, continuous galvanic current, it is observed that at the instant it commences to flow, there is a quick contraction in the muscles of all the limbs; but after that, and as long as the current then continues to flow *undisturbed*, even if for a long time, no more contractions appear; and the exposed spinal cord itself even, remains insensible to any stimulus whatever that may be applied to it; as, for example, pricking, pinching, heat, or induction currents; nevertheless all remains perfectly quiet. But, after the cessation of this current through the exposed cord of the mutilated animal, then again will the mere mechanical touch, or the reversed electrical excitation of the cord, give rise to twitchings of the muscles, and even contractions of the limbs, if the animal is still alive, and that in a

* Die Inductions-Electricitat, Nurnberg, 1857, p. 102.

greater degree than before. From such premises, surely, the author can never concur in the somewhat general opinion, that any considerable employment of the so-called constant galvanic current upon the human organism, *has necessarily, a paralyzing effect.* That paralysis, as well as a paralyzing tendency, can be produced by an injudicious use of electric currents, and that more readily by the galvanic, than the Faradaic currents, the author concedes. But, because the former has more power and uniformity of effect, upon and through the large nerve trunks particularly, is the reason why, when correctly employed, it is so greatly valued by the author as a therapeutic. In the most recent and popular work published in England on this subject, — and it is a most excellent work in many respects, — it is laid down as true, that "if the continuous galvanic current is allowed to traverse the spinal cord, then there is produced '*a paralyzing effect*,' whatever may be the point to which the poles are directed." Again: "The inverse continuous current [galvanic] is more powerful *for paralyzing* the spinal cord than even the direct galvanic current." Such, indeed, are the generally received views. Dr. Duchenne has also, in this direction, powerfully convinced the medical world, and greatly deterred from the employment of galvanism; but such views certainly do not accord with my own clinical experience, and therefore I cannot adopt them.

The *anterior roots* of the spinal nerves, according to Dr. A. Shaw, as should be mentioned here, arise by numerous fine radicles from the very *surface* of the anterior column, thus apparently showing that the part of the cord from which they derive the power of motion, is situated *superficially.* The posterior roots, on the contrary, dip boldly into the interspace between the posterior lateral, and posterior columns, and they reach a deep part of the organ before they subdivide to form any perceptible connection with the spinal cord; in short, the mode of the origin of the posterior roots is quite different from that of the anterior, and from their passage so deeply into the interior it may be inferred that the part of the cord which bestows sensibility is situated deeply. These views throw light on a fact

which must have been frequently observed in cases of disease or injury affecting the spinal marrow; namely, that the power of motion is commonly lost *before* sensation, or is destroyed to a comparatively *greater* degree. The explanation of this seems to be, that the morbid action affects the column of motion, situated superficially, before it can reach those of sensation, which are placed more deeply in the cord. In regard to the proofs which may be drawn as to the exact columns of the spinal marrow, which confer sensation from tracing the roots of the fifth cerebral nerve to their origins, some dissections described by Sir Charles Bell, in his later papers to the Royal Society, seem to be of peculiar interest. The fifth nerve, he says, resembles the spinal nerves in having two roots, one of which bestows motion, and the other sensation. It arises at the base of the brain, from the side of the *pons varolii*, apparently at a very remote distance from the spinal marrow. It is well known, however, to anatomists that the larger root, proved to be that which gives *sensation*, has its real origin from a point which may be considered the commencement of the spinal marrow. On following the thin, flat, ribbon-like band of medullary matter, which forms the proper root downwards through the medulla oblongata, Sir Charles Bell was satisfied that it did not pass in the direction of the posterior column, and has no connection there. He observed that it took a more lateral course, and disappeared in a tract which he regarded as the continuation of the posterior lateral column. From the same column he also found posterior roots of the spinal nerves arising, and he consequently inferred that it is the posterior *lateral* column, and not the main posterior, which is the source of *sensibility* in the great spinal cord.

The "*cilio-spinal region*" is that portion of the spinal column included between the seventh cervical and sixth dorsal vertebræ. This term originated with Professors Waller and Budge, who first observed that when this region of the spine is strongly excited by Faradaic current, the impression is transmitted through the cervical sympathetic nerve and ganglia, (the roots of which emerge from that part of the spinal cord,) it then

anastomoses with the nerves of the face, and also animates the *radior fibres* of the iris, and these act as the *dilators* of it. If, then, the cervical sympathetic nerve be excited, at the upper portion of the spine, by electric currents, the radial fibres of the iris very decidedly contract, as any *extensor* muscle, and thus overbalance, at least for the time, the circular fibres of the iris; for these latter, it is well known, act as the *constrictors* of it; and hence dilatation of the pupil must result. It is further found, that by the section of this particular nerve, the pupil of the eye becomes greatly and permanently *constricted*. The circular fibres of the iris, not being ramified by this nerve, are left to act in their normal state; while the section has caused in the radior fibres a complete paralysis, and consequently a preponderating, permanent constriction of the pupil of the eye.

Effects of Electric Currents on the Organs of Sense.

For operating on these, we may choose an instrument out of any of the *three classes* of machines that we employ for producing electricity, as all forms of it act upon the organs of sense, but differently, though all are admissible. From my own experience, and that after due consideration, I am disposed to decide that the primary galvanic currents have the most marked and beneficial effects on these delicate organs when they are deranged and diseased. I am not alone in this important observation, and if most effective and remedial here, why not elsewhere in the organism? To use the galvanic current for *arousing action* and toning-up, as in cases of nervous deafness, and nervous blindness, whether complete or partial, — of debilitated eye muscles, or deficient secretion, or even where excessive and morbid secretion of the lachrymal and salivary glands, — then I should say one electrode must be situated low on the cervical portion of the spine, while the other is directed to the part affected. In these cases we should always be careful to begin very gently, as with only one element of a Daniell's battery, or with but the the very least electro-magnetic current, and then feel the way up the scale to a point of bearable endurance; but never in any

case do I allow more than ten cups or elements to be thus employed in the applied current, and but very seldom that number. For safety, as well as for *toning up*, the direction of the current should be reversed suddenly, as by the *current changer*, say every fifteen seconds, and then quite suspended after each minute, for at least a few seconds. The *seance* may occupy ten or fifteen minutes, but the time of the actual working of the current in all should never exceed from two to five minutes.

1. *Seeing.*—The normal action of electricity on the organs of sight, i. e., in health, is varied according to its *form* and *application.* If static electricity is applied by sparks *drawn* from the surface of the closed eyelids, there is produced not only the redness of the skin, showing increased circulation there, but the person probably sees faint luminous flashes, or sparks; and this, if not too far prolonged, is followed by an increased functional capability of the whole eye. These sparks should be so graduated in their *length* as to be bearable, and their succession not continued more than a minute at a time. If we employ electro-magnetism, the superficial portions of the eye respond to its effects, while the retina appears to be but very little reached by it; at least the author has never known the luminous flash or spark to be produced by it. If the magneto-electric currents are employed as strong as they can be borne, and with the switch of the machine set so as to give only a one-way current, then, if the positive pole is placed over or near the eye, the retina is decidedly affected. If primary *galvanic* currents are directed to the eye or eyes, by placing the small moist sponge electrode over the closed eyelids, and thus *upon* the eyeball, then the moderate, constant, and steady current produces no other *sensible* effect than a slight prickling in the skin of the eyelids; but if now the current is interrupted, reversed, or varied in density, then there is produced a flash of light as often as the interruption, reversion, or other variation is repeated. This is no actual development of electric light, as might by some be supposed, but merely an instantaneous increased action of the retina. The third nerve, if involved in any lesion, arising as it does from above the bifurcation, ought

to be affected on the same side; and so it is always found: the pupil on that side is dilated, and seen to be larger than the pupil on the unaffected side of the body. Besides, it is not necessary to apply the galvanic current to the eye at all in order to produce this luminous flash or spark; nor yet is it required that some branches of the *tri-geminal* should be embraced by the electrodes. Through the mysteries of reflex action, this phenomenon is frequently produced while operating with galvanic currents about the branches of the cervical ganglia in the neck, as also about the head while treating for crown headache, or for nervous deafness, or contractions of the occipital portions of the *trapezius*. Indeed, this was noticed long ago; for Dr. Achard, of Berlin, by actual experiment, found, "that if one pole of a considerable voltaic pile was placed in the mouth, and the other in the rectum, *there was seen a flash of lightning*" at every closure and opening of the chain.* (See p. 641.)

But if the wet sponge electrode is pressed upon the closed eyelid, while the other electrode is on the upper part of the spine, then at every sudden application, variation, or interruption of the active galvanic current, the flash will appear; and the degree of this is in ratio with the intensity of the current employed, and inversely to the resistance, or failure of in-working. This flash evidently results from a direct electric excitement of the retina. If the *positive pole* is over the eye, the flash is purple or bluish; but if the negative pole is there, then the flash is a pale reddish yellow, or an orange-colored light is seen. These luminous flashes are the brightest at the circumference when the negative pole is to the eye, but the lightning flash is uniform when the positive pole is placed there.

The Iris. — If we direct one pole of a very moderate electro-magnetic or galvanic current to the most prominent portion of the cornea, while the other electrode is placed upon the face, the circular fibres of the iris are seen to contract, not slowly, but most promptly, much as do voluntary muscles; and when the

* Versuche Uber die Gereizte Muskel und Nervenfacer, by Von Alexander Humboldt. Berlin, 1797, vol. i. p. 334.

current is opened, the contraction of the iris *as instantly* ceases. If the small sponge tipped ivory electrodes are now applied to the opposite edges of the cornea of one eye, or a little farther back on the sclerotica of the eye, then the *radiar* fibres of the iris are extended, as is an extensor muscle, and thus the pupil is enlarged. If these little electrodes are applied to the right and left of the eyeball, the pupil then assumes the form of an egg standing upon end; if the electrodes touch the eyeball above and below, then the oval pupil is horizontal. Thus we can act on the iris of the eye by the electric current so as to contract or dilate the pupil according as we direct the electrodes to the *sphincter pupillæ*, or to the *dilator pupillæ*. The pupil of the eye in man can thus be constricted simply by means of a single voltaic pair, as by my local silver battery, if the one metal is placed in the nostril, while the other is upon the tongue; and then — the patient sitting in the mildest light of the room, where there is only just light enough to see the oscillations of the pupil, — upon making and breaking contact between the two metals by the clasp of the insulated conductor, the pupil is seen to dilate and contract; or, rather, to contract with the contact, and to dilate with the breaking of the circuit.

1. The External Opening into the Ear at the bottom of the *Concha*.
2. The Meatus Auditorius Externus, or cartilaginous canal.
3. The Membrana Tympani, stretched upon its ring.
4. The Malleus.
5. The Stapes.
6. The Labyrinth, where is also the loop fringe of the Auditory Nerve.

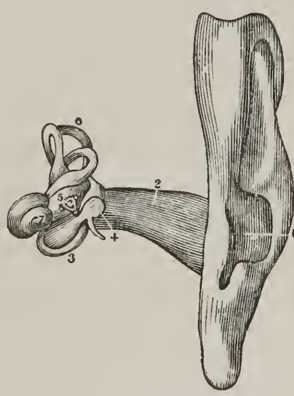


Fig. 57. An Anterior View of the Left Ear, showing the External Ear, the Meatus Auditorius, the Labyrinth, &c.

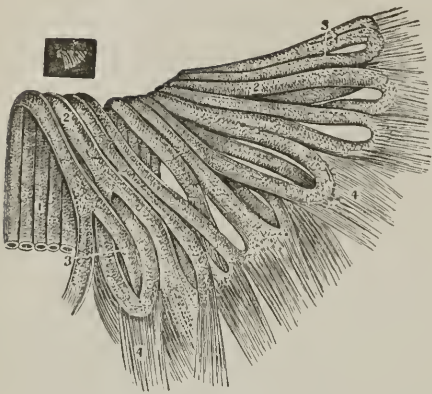


Fig. 58. A View of a small piece of the terminal loops of the human Auditory Nerve; being highly magnified, so as to show the tubular structure of the nerve fibrils, and the manner in which they leave their Neurilema as they anastomose with the layer of the Zona Membranacea.

1. Shows the distinct and tube-like form of the Nerve Fibrils, as they occupy the Osseus Canals in the *Zona Ossea* of the *Lamina Spiralis* in the Internal Ear.
2. The natural size of this piece is seen just over this figure, that is, the same as we see magnified.
3. Anastomosis in the *Zona Mollis*.

4, 4. The Neurilema leaving the Nervous Loops, or rather extending and interlocking to form with the membrane of the *Zona*.

2. *Hearing.* — The normal effects of electricity on the auditory nerve and organs of *hearing* are mostly those of increased noises, as roaring, scratching, and dropping, or of painfully exalted hearing and throbbing. But all these are greatly varied, according to the kind and method of electricity employed. The induction currents, as employed and advised by Dr. Duchenne, and so generally adopted by physicians as the electric remedy, are usually a failure. To fill the ear with water, and then maintain the point of the electrode, during the *seance*, deep in the water and near to the tympanum, and that without touching the sides of the canal, is easier advised than done; besides, the patient will tolerate only so slight a current, that the result is apt to be fruitless. For these reasons, the author has abandoned that method entirely. From long experience he finds the following a more practical and successful method for this operation in the ear: First, to put into the ear of the patient one or two drops of warmish water. If by accident more is dropped, turn the head over to that side and work it out. Then adjust one electrode low on the back of the neck, which may be the large, flat, moist sponge, while into the meatus of the ear is

introduced another tiny electrode, made for the purpose, of ivory, silver wire, and sponge, so as to insulate the wire excepting its ends. This ivory *ear electrode* is two inches in length, one quarter of an inch in diameter at the outer end, and then tapered down to one twelfth of an inch at the smaller end. This is perforated lengthwise, so as to take a double loop of fine silver wire, that seizes a bit of the finest sponge, which is drawn firmly into the little cupped end of the ivory tube, and then clipped into a ball-shaped tip, while the wires pass through the instrument and appear at its outer end, where they are secured and exposed convenient for contact. When this delicate instrument is carefully introduced into the ear, so that the moist sponge rests gently, and not painfully, against the moist membrane of the tympanum, and the patient is sitting in a reclining and easy posture, while the operator is seated behind him, then, whether employing primary or secondary, i. e., Faradaic, or Galvanic currents, the making and breaking of the circuit is done simply by applying the wire tip of the battery conductor to the silver projection of the ear electrode; and this will be found both practical for the physician and agreeable to the patient, and attended not unfrequently with success, even in the very same cases where the old method had been attempted in vain. In this manner, the patient can bear more current, while this is all the better concentrated upon the enfeebled or paralyzed auditory nerve and the minute muscles of the internal ear, so that the operation is left more to the judgment of the physician than to the sensations and requests of the patient. For these reasons, we are to proceed with the utmost caution. It should be borne in mind that the zinc or *negative pole* produces the greatest effects in the *ear*, while it is the silver or copper *positive pole* of the battery that exercises the greatest effects in the *eye*, *nose*, and *mouth*. The galvanic current makes a sound in the ear *when* the circuit is closed and *while* it remains closed, growing more and more intense until the circuit is opened. The induction currents cause the sound of a scratch; or, if prolonged, the sound is like the buzzing of a fly, or the distant steam-whistle. Dr. Ritter says the pitch of these sounds is that of G. Dr. Althaus says it

is that of A. The *intensity* of sound is as the intensity of the current and the state of the nerves, but the *pitch* is always the same. While treating the ear with electricity, and particularly if we employ galvanic currents, we may have, now and then, extra-polar workings, manifested by a metallic taste, or even by a flow of saliva if the current is strong or long continued, or if the nerves are in a state highly susceptible. By this unpurposed electro-physiological test, we ascertain that the *chorda tympani* is intimately connected with the sense of taste. This is corroborated by clinical experience; for in some cases of palsy of the *portio dura*, there is also loss of taste on the same side with the paralyzed muscles of the face, which also disappear together. The extra saliva that flows, and the inclination to deglutition during the action of the current upon the drum of the ear, probably proceed also from the chorda tympani, *or are the result of reflex action;* I am inclined to believe the latter. (See p. 644.)

The author would here remark, as the result of long and often repeated observations, and as an important item in the general prognosis of all nervous affections, that where the external ear of man, woman, or child, is seen to be *not well turned and full formed*, i. e., where the helix or external rim of the ear is decidedly deficient, particularly if with this the upper portion of the ear is *delicate*, *thin*, and *dwarfed*, or even where the whole ear is unusually small, crumpled, or deformed, wanting either in substance, posture, or well-developed outlines of plumpness and curves of beauty, — in such a person, the nervous system is also peculiar; *there is a great liability to some nervous affection.* My experience authorizes me to state, that in nearly seven cases out of every ten of all such persons so marked, there is already manifested some nervous derangement or confirmed nervous disease. According to my observations, there is the *coincidence* at least, that the nervous system of such individuals is either imperfectly developed or unduly developed, (in given parts so as to constitute unbalanced nerves,) for certainly such persons are peculiarly *prone* to pain, palsy, chorea, incurable hysteria, and hypochondria, or insanity; such like accidents appearing from no cause, or from the slightest causes. But what is still

more interesting to medical men, is the equally apparent fact, that when such patients are restored after the greatest vigilance and most persevering treatment, *they, of all cases, are the most liable to relapse*, and that from the least exposure.

The knowledge of this may be of value to many, because we may sometimes say to such persons or their friends, "*Beware;* do not over-tax or fret, but rather try to physically develop, for *here is a delicate nervous system.*" If the individual is already affected with some nervous derangement or disease, then our prognosis must be all the more guarded and prudent; but at the same time advising, if possible, such measures as will secure the attainment of *ordinary powers of endurance.*

3. *Smelling.*—The normal action of electricity on the organs of *smelling* is more that of a simple stimulus, or irritant, than a direct helper in the physiological function. The *Schneiderian membrane* receives the impression from electricity as if painfully scratched, but without any increased power for smelling. The *sentient nerves* prevail here, as they do upon the face, only more so. Dr. Ritter appears to have been the only one to experience in his own person, in this respect, the effects of a very strong electric current. He used a voltaic pile of twenty-five pairs, and the effect on him was terrible. He found the effects different according to the *direction* of the current. When the current was inverse, then, both at the commencement and while the circuit was closed, there was a sense of acidity, with a loss of the sneezing faculty; but at the cessation of this current, and for a short time after, he perceived an ammoniacal smell, with an *increased* capability for, and disposition to, sneezing. If the current was reversed, then the reversed results ensued, namely, ammoniacal smell and sneezing on *making* the current, and as long as it continued; then the acid taste, and loss of power to sneeze, occurred on breaking the circuit, and for a little time after.

It is probably familiar to all who use the friction machine that when the disruption discharge is allowed to take place without a spark, as from points, and hence without heat, the oxygen of the air is thus modified, and ozone is evolved. This is sensible to the smell like that of a phosphoric and sulphurous odor, or as

something in the atmosphere; but this does not affect the state or action of the olfactory organs. The fact is, the author has almost nothing, from his own experience, to state under this head; but if he had positive occasion for the employment of this agent here, he would make the application rather to the external portions of the nose than to the nasal membrane, except in a paralysis, or such lost degree of sensibility that some few elements, at least, might be tolerated by the patient. The positive electrode to the interior of the nose has more effect than the negative.

4. *Tasting.* — The normal actions of electricity on the *mouth*, and organs of taste, are certainly as curious as useful. Galvanic currents are here very sensitively felt, producing a metallic, sour, or alkaline taste, twitchings of the tongue, increased flow of saliva, flashes of light, pain, prickle, and heat. Faradaic currents, if here moderately applied, produce only twitchings of the tongue. Frictional sparks act here more as do galvanic currents. It is supposed that these different phenomena are brought about by the action of electricity *through the gustatory nerve*, just as *sensations* of light are induced by it, when directed to the retina; or of sound, when directed to the auditory nerve.

5. *Sentient Nerves.* — Healthy skin nerves, which we know are the *nerves of sensation*, or sentient nerves, are observed by the aid of a microscope to be arranged in their peripheric terminations much like fine moss, or the pile of fine, uncut, silk velvet. If the direct action of a considerable galvanic current be brought to bear upon the skin, and thus *immediately* attack those nerves, there is produced a sensation of warmth, heat, or burning, with another sensation of together-drawing, pursing, or contraction, with a prickling or pain, — one or more, in proportion to the *strength* of the battery, to the *sensitiveness* of the skin, and to the *in-working* of the current. These sensations, or some of them, may continue as long as the circuit remains closed upon them, and that with a rapid increase in degree, until quite unbearable. If, then, the action of this current be still maintained for a long time, i. e., like an overdose or abusive use of a powerful medicine, then there is produced a *diminution* of

these sensations. Indeed, if it should be still longer continued, and a still stronger current be employed, there could be produced a sensation of numbness, and perhaps of coldness, which remains a few minutes after the current is removed. Then the physiological sensations soon return again, however, with a somewhat increase of function.

If electro-magnetic currents are thus brought to bear upon these nerves through the skin, then sensations are produced which vary according to the *intensity* of the current, the *rapidity* with which it intermits, and the *sensitiveness* of the skin. The sensations are different, also, on different parts of the body and limbs. They may be extremely pleasant, or as extremely disagreeable, or even intolerably painful; or there may be a together-drawing, contracting, pinching, pursing, prickling, or, as sometimes experienced, a burning sensation. These cease when the current is opened. An induction current of the same quantity and intensity has a greater effect upon the sentient nerves, in proportion to the frequency of the interruptions of the current, *up to a certain degree*, which, for instance, may be about all the nerves can bear; but if the vibrator is screwed up a trifle, so as to make the interruptions extremely fine and rapid, then the current is more easily borne, and not only so, but it then becomes almost or quite pleasant, particularly if it is being applied to the back or shoulders. But I believe there is in this case more indirect effect; i. e., *reflex action*, because this current more nearly resembles the continuous galvanic current. A pretty rapidly interrupted current has more effect on the sentient nerves than very slowly interrupted currents, because *it is the law of their action to feel or retain the effects of an impression for some little but appreciable time*, *after being acted upon.* So where a sentient nerve, that is in health, is subjected to the action of a single blow of an induction current, if of low tension, there is almost no sensation; but if these blows or shocks are then *repeated* faster and faster, the sensations will likewise increase, because the sentient nerve is not now in its normal state, i. e., when it receives the second, and third, and succeeding shocks, but is in an excited condition, or polarized. Thus it is easy to

understand why the sensations produced by the induction currents increase in proportion to the velocity of the interruptions, to a certain degree. So much for the *immediate* sensations. Generally speaking, if the continuous, smooth, or even action of a moderate Galvanic or Faradaic current be directed through a *sentient nerve*, in a *direct* or down-running direction, then there is produced a quieting, diminishing, or *down-toning* effect. If, on the contrary, the current be directed so as to flow through the sentient nerve in an *inverse* or up-running direction, then there is produced an *increased*, *exalted*, or *toning-up* effect; that is, in the former case there is produced *diminished sensation;* in the latter case, there is produced *increased sensation.* This rule is even still more marked, when these currents act upon sentient nerves that are sick and morbidly increased in their sensibility, as in cases of true local neuralgia. But these valuable "*general principles*" are still further influenced by the kind of *electrodes* that are used in the trials, and by the *method* of managing them and the current. For *quieting these nerves*, we should always choose broad, soft, warmish and moist electrodes, as fine and soft sponges, which are to be gently applied to the skin, within a few inches of each other, and kept in gentle but ceaseless motion, with a careful and gradual letting on of the current, and as gentle and gradual taking it off, after an application of a minute or less. This may be repeated, after a recess of a few seconds, for some half a dozen times, at the same *seance.* If not successful, these seances, or sittings, may be repeated every few hours. But for cases of anæsthesia, and wherever we wish to arouse and *wake up* sensation, then not only must the current be *inverse* in direction, but it may be interrupted, or reversed, or alternated, from second to second, and that through *small*, say one inch ball, *electrodes*, covered with wet *wash-leather*. The current, here, too, should be strong, and it must be let on, reversed, and interrupted *suddenly*, but not continued more than a minute at a time. One electrode may be placed *over the nerve-trunk*, *while the other is moving over the palsied periphery*, *or border points of the palsied muscles.*

According to the laws of Marianini, as they relate to the phys-

iological effects of electric currents on the *sentient nerves*, we gather the conclusion, that the sensations caused by the application of the continuous current of electricity are strongest on *closing* the *inverse* current, and on *opening* the *direct* current; but the contrary takes place when the *motor nerves* are acted upon; for muscular contractions are more readily produced on *closing the direct*, and on *opening the inverse*, current; for this reason, therefore, if mixed nerves are electrized, we obtain the following

Effects on the Mixed Nerves.—

Direct current.	Closing the circuit — Contraction. Opening the circuit — Sensation.
Inverse current.	Closing the circuit — Sensation. Opening the circuit — Contraction.

When we electrize mixed nerves, the phenomenon that results is due to the peculiar excitation of the filaments of both sentient and motor nerves of which they are mutually composed, and hence, to a greater or less degree, to *reflex action*. But the *direction* of the current mainly determines the *physiologic* and the *therapeutic* result. Hence, this rule is held to be the fundamental, viz.: *that the direct current can produce powerful muscular contractions with comparatively little sensation, or pain; while the inverse current can produce greater sensation, or pain, and that with greater "reflex action;" while the muscular contraction is comparatively weak, or even totally wanting; also, that the reversing the direction of a current from second to second, increases its exciting, reflex, and constitutional effects.*

According to the *law* first laid down by Dubois-Reymond, it is moreover perfectly easy to understand the action of electro-magnetism, and other *induction* currents upon the motor nerves and muscles. The physiological action is in this case the greatest possible for the given amount of electricity, as to quantity or intensity, that actually courses through the nerves. These currents are necessarily made up of the least conceivable *bits* of currents, which are instantaneous, succeeding each other with the greatest rapidity, in consequence of the make and break in the inducing current of the battery, or of the approach and leaving of the magnet, &c. But, I ask, must it necessarily fol-

low that the current that produces the greatest possible effects, *as manifested by contractions*, must therefore *always* be *the most remedial* in effect? I think not; although, in fact, it may yet be proved to be so. Where the action of the current is indicated for exercising the deep muscles, such as cannot be done by passive motions, nor yet by any kind of mechanical manœuvres, these currents act admirably. But where there is required a catalytical action in the molecular structure of the tissues and blood, and for reëstablishing the dominion of volition, or, as we call it, the *will*, then, if not contra-indicated, the galvanic currents not only seem, but prove to be more powerfully restorative. Notwithstanding, we must bear in mind that it is the opinion of Dr. Duchenne and many other experienced medical electricians in Europe, "that *induced* electricity is essentially medical electricity."

There can be summed up the following *rules:* If the electric current be directed through a motor *nerve*, then will the whole deep substance of all the muscles, which are animated by ramifications of that nerve, enter into contraction. But if the current be applied directly *to the muscle*, then *only* those fibres are seen to contract, which are nearest the electrode, and traversed by the current.

Effects of the Electric Currents on the Motor Nerves.

If a galvanic current is directed through a motor nerve of the recently-killed animal, contractions of all the muscles that are ramified by this nerve are produced on closing as well as on opening the circuit; and that, too, whether the current be down-running (direct), *or up-running* (inverse). Now, this will fail to be done, if one electrode is applied, say to the right of the nerve trunk, while the other is to the left of it; for in this case the current will pass transversely across the nerve. Therefore we must be particular to place the electrodes *over two points of the nerve;* or the one over the *nerve*, while the other is on the *depending muscle;* in either case, the one is to be so situated above the other, that the electric current will traverse the nerve

in a longitudinal direction; or, better still, if in a somewhat *oblique and longitudinal course*, so as to thus embrace the greatest possible number of nerve filaments, although the position of the electrodes on the skin may be close together.

Muscular contractions in the living human organism cannot be produced from the excitation of pure motor nerves by an electric current, *unless* those nerves are in some little degree or sense possessed of their normal integrity. True it is, that the electric stimulus is capable of so disturbing the molecular equilibrium of the motor nerves and their depending muscles, as to produce the state in which they are physiologically active; and this disturbance, if judiciously made, does not cause any injury to nerve, muscle, or central organ, but rather tends to *reëstablish* the lost or impaired vital functions of the reciprocal actions of nerve, muscle, and central organ, whenever so lost, provided they are under the above conditions. Dr. Bernard has shown that if a motor nerve is galvanized, while in its normal physiological condition, — i. e., while it is still connected with the spinal cord of the living animal, then a contraction is produced *only* on *closing* the circuit, be the direction of the current either direct or inverse. But if the nerve is some *fatigued* by energetic or very prolonged action, by heat, or by any other means, then *two* contractions are produced by either current, the one at the closing of the circuit, and the other at its opening. Therefore, if this phenomenon is observed in practice, we calculate that the nerve is *fatigued;* i. e., it is in a degree exhausted. Then, again, if the fatigue is greater still, the contractions are only observed on closing the direct, and opening the inverse, current. If the fatigue is still greater, we obtain only a single contraction, and that only on closing the direct current. Then, if the fatigue is even greater still, and the exhaustion is *total*, — i. e., complete and final, — there is no more contraction produced under any circumstances whatever. *This is strictly peculiar to the nerves of living human beings.*

Again, we have already shown, that during the time a continuous, moderate, and even-flowing galvanic current is traversing a motor nerve, *no visible contractions occur*, although a real

catalytical and polarizing effect *is as certainly in progress.* But the visible physiological effects that are manifested by contraction, occur rather at the moment when the density of the current suddenly rises from *zero* to a certain height, as is the case on establishing the circuit, and also when the density of the current descends again from a certain height to zero, as occurs on breaking the circuit. Setting out with these facts, Dr. Dubois-Reymond gives us a great *electro-physiological law* for the motor nerves in the following terms: "The motor nerve is not excited by the *absolute amount* of the density of the current of electricity, but merely by the variations which occur in the density of that current from one instant to the other; and the physiological effect is the greater, the more considerable are the variations of the density of the current; that is, in proportion as the variations take place less or more rapidly, or as they are more considerable in a given space of time." *

But we can say still further, that it is *not* absolutely necessary to actually *break* the current that is traversing a nerve in order to produce contractions; for these physiological effects are brought about even by the minor variations in the density of the electric current, as is shown by moving one of the electrodes a little farther from the other while the current is flowing, and while both electrodes remain on the skin; or by now pressing the electrode more or less; or it can also be done by increasing the current from switching on other series of cups through the key-board, or by quickly taking a portion away, or by diverting a portion of the current. But this power will be shown still more, if the direction of the current is *suddenly reversed* every second, as by the *current turner* of the key-board, although the current is constantly flowing; besides, this latter effect is observed to be more and more powerful, for a time at least, until the nerve is over-fatigued, or exhausted, when it will be observed to diminish; but that diminishing I do not call paralyzing *in any sense of the word*, more than hard work is paralyzing; unless they are carried to great extremes as to

* Untersuchunger uber thieristhe Elektricitat, Berlin, 1848, vol. i. p. 258.

power, and length of time continued, &c. Either work, or Galvanism, and Faradaism, may be injurious, when thus made empirical and abusive. *Feeble muscles and limbs can be rubbed by strong hands, until they are powerless.* Joints that are stiffened and weak may be readily over-exercised, so as to be more helpless than before. I have seen cases of "wasting palsy" brought to my rooms that had been "*so faithfully*" and perseveringly shampooed with some prescribed liniments, or with coarse, wet towels, and that, too, by the advice of the medical attendant, performed perhaps by the devoted mother from the highest motives of love and duty, — so overtaxed *by these means*, — that the process of atrophy and degeneration had gone on with most shocking and astonishing rapidity, and to a degree altogether incredible unless observed.

For these reasons, the author is all the more inclined to interpret the *over-long*-continued action of a medium faradaic or galvanic current, either on a motor, sentient, or mixed nerve, in the first instance, *as pre-occcupying* or *diverting the normal nerve action*, and which is sooner or later followed also by a fatigue, and then an exhaustion that is speedy in proportion to the strength of the electric current, and the endowment of the nerve; much the same as is produced by very violent, unremitting, and protracted labor; only the electric current's effects are quicker and more complete than labor's effects in producing this class of results, and can act where labor cannot be brought to bear.

Effects of Electric Currents on the Sympathetic Nerves.

The earliest experimental researches on the ganglionic or sympathetic nerves, says Dr. Althaus, were undertaken in 1727, by Dr. Pourfour, who found that from the section of the cervical filament of the sympathetic nerve, the following phenomena are observed; a contraction of the pupil of the eye; a flattening of the cornea; a redness and sometimes injection of the conjunctiva; the secretion of the palpebral mucus is increased; the eyelids are partially closed, and the third eyelid, as in birds,

is large; the *nectitant membrane* becomes prominent and advances upon the eyeball. If the animal then continues to live a certain time after the operation, the eye becomes smaller and in effect shrunken, and drawn back in its orbit. These experiments were repeated and confirmed by Dr. Pupuy, Dr. Breschet, and Dr. John Reid. But more recently it is discovered, that if the pupil has become constricted after the section of the cervical sympathetic nerve, it can again be dilated if the cephalic end of the nerve be electrized.

In the year 1852, Professor Claude Bernard published his most interesting and valuable researches on the physiological offices of the great sympathetic nerve. He goes on to say, that after the section of the nerve, or after the destruction of the superior cervical ganglion, besides the phenomena long before noticed by M. Pourfour-du-Petit, the following are produced: a less or greater constriction of the nostril, and of the mouth, on the same side; an increase in the circulation of the blood, with an augmentation of heat and sensibility in the head. He observes, also, that if the cephalic (upper) end of the cut ganglionic nerve be electrized, then all these phenomena observed after, and in consequence of the section of the nerve, will equally disappear, and can even be exaggerated in the extreme. Not only does the constriction of the iris, that is produced by cutting the sympathetic nerve, disappear from being electrized, but the pupil becomes even larger than normal; the eye is plumper and more prominent; the temperature, which had been exalted, is diminished to a healthy standard; the nostril and ear of the animal, which had been red and injected, become quite pale again; but as soon as the electric influence is removed, then all the phenomena that first attended the section of the nerve, gradually reappear. But they can be made to disappear, again and again, by the repeated applications of the electric current to the nerve above the cut. Besides, if we apply a drop of ammonia to the conjunctiva of a dog, in which the section of this ganglionic nerve has been made, the pain will oblige the animal to keep the eyelids strongly closed; and then, if the cephalic end of the cut nerve be electrized, he will immediately open his

1. The Plexus on the Carotid Artery, in the Carotid Foramen.
2. Sixth Nerve, (Motor Externus.)
3. First Branch of the Fifth, called the Ophthalmic Branch.
4. A Branch on the Septum Narium going to the Incisive Foramen.
5. The Recurrent Branch, or Vidian Nerve, dividing into the Carotid, and the Petrosal Branches.
6. The Posterior Palatine Branches.
7. Lingual Nerve joined by the Chorda Tympani.
8. Seventh Pair, also called the Portio Dura, or Facial Nerve.
9. The Superior Cervical Ganglion.
10. The Middle Cervical Ganglion.
11. The Inferior Cervical Ganglion.
12. The Roots of the Great Splanchnic (sympathetic) Nerve arising from the Dorsal Ganglia.
13. The Lesser Splanchnic Nerve.
14. The Renal Plexus.
15. The *Solar Plexus.*
16. The Mesenteric Plexus.
17. The Lumbar Ganglia.
18. The Sacral Ganglia.
19. The Vesicle Plexus.
20. The Rectal Plexus.
21. The Lumbar Plexus, (Cerebro-Spinal.)
22. To the Rectum.
23. To the Bladder.
24 The Pubis.
25. The Crest of the Ilium.
26. The Kidney.
27. The Aorta.
28. The Diaphragm.
29. The Heart.
30. The Larynx.
31. The Sub-Maxillary Gland.
32. The Incisor Teeth.
33. The Nasal Septum.
34. The Globe of the Eye.

35, 36. The Cavity of the Cranium.

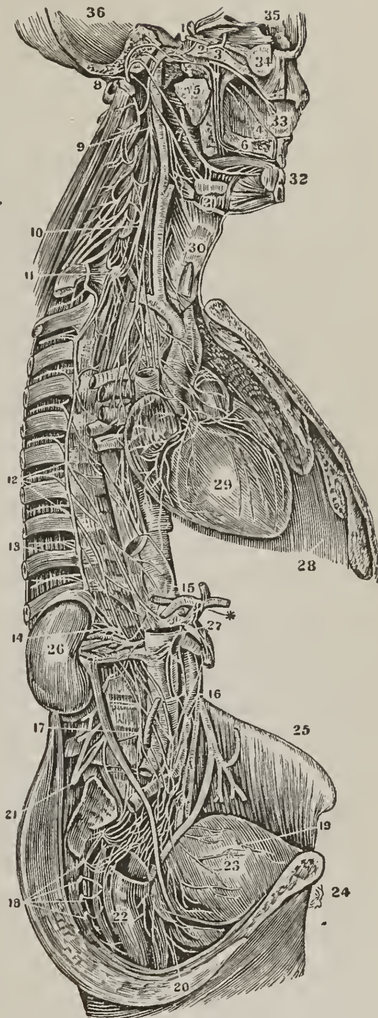


Fig. 59. A View of the Great Sympathetic Nerve, also called the "Ganglionic System of Nerves," and showing the relative position, as also the communication, of several other nerves.

eyes again, notwithstanding the pain he is all the while experiencing; nor indeed is he able to shut them, for they are kept open as long as the current traverses the nerve, while the redness caused by the ammonia also diminishes, and soon entirely disappears.

According to Dr. Althaus, of England, we see that these phenomena have been investigated by many scientific men, as Dr. Augustus Waller, of Birmingham; Professors Budge and Schiff, of Berne; and Dr. Brown-Sequard; all of whom corroborate these facts, and besides have added new ones regarding the physiology and pathology of the sympathetic nerves, all of which may be given as follows: By a section of the cervical ganglionic nerve, nearly all the *muscles* of the eye and of the angles of the mouth, and of the nostril, become permanently contracted. The ear of the animal is held erect; the quantity of blood, not only in the ear, but in that whole side of the head, is decidedly increased; the arteries are fuller and beat with more force; the temperature is increased for a length of time; the current proper of the muscles is stronger; poisons and other substances which are deposited in equal quantities on the two sides of the head,—i. e., under the sub-cutaneous cellular tissue of the face, or at the base of the ears,—are found to be *more rapidly absorbed on that side where the section of the nerve had been made;* but *chloroform destroys the sensibility there much slower* than on the sound side; the *rigor mortis* appears *later*, and lasts longer; putrefaction begins later.

It is found also, that nearly all the phenomena observed as the consequence of severing the cervical sympathetic, may be produced by any means whatever that will simply increase the amount of blood circulating in the blood vessels of the head in a given time; as by holding the animal up by its hinder legs, which produces a strong congestion of the head, and contraction of the iris, &c. Hence we infer, that all, or nearly all, these phenomena are due to the deranged condition of the blood vessels, brought about by the division of the cervical nerve, thus enlarging their calibre and allowing more blood to pass through these vessels in a given time. When the entire *cervical sym-*

pathetic nerve is electrized actively, i. e., *severely*, we find the following results: An opening of the eyelids; a dryness of the cornea and conjunctiva; a dilatation of the pupil; a contraction of the blood vessels of the whole eye, and consequent diminution in the quantity of blood there; a decrease of temperature and of sensibility; the nervo-electric current proper of the muscles of the eye is less; the excitability of the motor and sentient nerves of the iris, as also of the muscles, together with the contractility of the arteries, disappears sooner, after death, than on the other side; the cadaverous rigidity and putrefaction commence sooner than on the sound side, because of the greater electrolytical or chemical changes produced by the powerful and prolonged action of the current on the nerve and tissues.

M. Bernard says, if the external auricular nerve, which takes its rise from the cervical plexus, and transmits the reflex action from the external ear to the spinal cord, and thence to the great sympathetic, be cut across, the increased temperature of the external ear that is thus produced cannot be lowered to its natural standard again by the direct means of induction currents to the lobes of the ear; while if the application be made rather to the cut cerebral end of the sympathetic branch, then the temperature immediately decreases to its normal standard. On the other hand, if no section of the cervical sympathetic nerve has been made, and the external ear is sharply Faradaized, then the temperature of the whole auricle is diminished.

It follows, therefore, that if we electrize the external ear, as by direct Faradaization applied to the upper or lower part of it, there is produced a different phenomenon, according as the section of the superior cervical sympathetic *has* been made or has *not* been made. Where the section of this nerve has been made, the ear becomes hot, &c. Then, if electro-magnetism be applied so as not to pass through the thin diameter of the auricle or external ear, but rather so as to traverse its *longest extent*, as from top to bottom, the temperature becomes thereby *increased;* but if the electricity is directed rather to the cephalic cut end of the sympathetic nerve on that side, the temperature is *diminished*. But this has been further illustrated by test. Dr.

Bernard electrized the long and delicate ears of a rabbit, in one of which he had already cut the left sympathetic nerve; while the other, on the right side, was left intact. Now, when the left ear was electrized, a rapidly-increased heat was noticed; but when the right ear was electrized, as rapid a diminution of heat was produced. He explains this thus: the elevation of temperature on the side where the nerve had been cut results from the circumstance that, under the influence of the *pain*, the heart acts more vigorously upon the arteries of the ear, which are already relaxed in consequence of the section of the ganglionic filament; while on the right side, where the nerve has not been cut, the electricity causes an excitation of the sentient nerves, which impression is transmitted to the spinal cord, and then again by a *reflex* to the sympathetic; hence the vessels of the ear are constricted, and therefore the action of the heart cannot produce the same results as it does on the other side, where no reflex action from the spinal cord to the sympathetic ganglia is possible.

Professor Weber discovered, in 1846, that where the *inferior* cervical ganglia of the sympathetic is electrized by an active induction current, the pulsations of the heart are greatly *increased*. The same phenomenon occurs, if the cardiac branches from this ganglia are subjected to the action of the current. But if the *vagi* are electrized the action of the heart is *diminished*. If the current be stronger, or longer used, the heart's action comes to a stand-still.

Professor Pflueger discovered, in 1856, that the splanchnic nerves exercise a similar controlling influence over the peristaltic movements of the intestines, much, indeed, as the vagi do over the contractions of the heart.* He found that when the electric current is applied to the splanchnic nerves, which take their rise from the six lower dorsal ganglia of the sympathetic, then the vermicular movements of the small intestines are very soon suspended. From this he inferred that there is a peculiar set of nerves for the *physiological action of diminishing*, or even suspending, the various movements of the intestines, and he designated them as the "*inhibitory system*" of nerves. But Mr.

* Uber das Hemmungs-Nervensysten fur die peristaltischen Bewegungen der Gedarme, Berlin, 1856.

1, 1. A line drawn from the highest point of one Ilium to the other, horizontally.
2, 2. A line drawn perpendicularly from the Anterior Superior Spinous Process to the Cartilage of the Ribs, just under the Nipple.
3, 3. A line similarly drawn on the opposite side.
4, 4. A line drawn transversely to these, (but parallel to the line marked 1, 1,) touching the most prominent parts of the Costal Cartilages, thus forming the *technical* Nine Regions.
5, 5. The Right and Left Hypochondriac Regions.
6. The Epigastric Region.
7. The Umbilical Region.
8, 8. The Right and Left Lumbar Regions.
9. The Hypogastric Region.
10, 10. The Right and Left Iliac Regions.
11. The lower part of the Hypogastric, sometimes called Pubic.

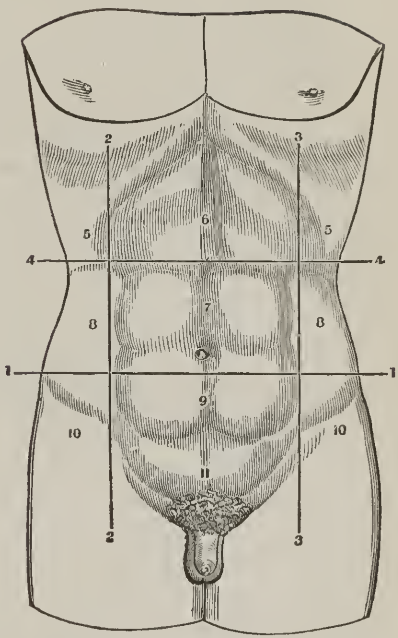


Fig. 60. A View of the "Regions" of the Body.

Lister has more recently found that the inhibiting effect through these nerves is produced only when the strongest currents are directed to the roots of the splanchnic nerves; *while, on the contrary, if more moderate currents are employed, there are observed accelerated peristaltic motions.**

Effects of Electricity on the Intestines, Uterus, and Secreting Organs.

Dr. Aldini observed, a long time ago, from actual trials, that the alimentary canal responds very remarkably to the voltaic current. Professor Achard, of Berlin, made the trial upon himself, and he testifies to the prompt and effectual action of electricity upon the functions of the bowels. It is an every-day occurrence to hear some patient testify to an unaccountable promptness of the movements of the bowels while taking treatments that require daily applications of Faradaic or Galvanic currents along the spine. As confident am I that the relaxed, inflated, and atonic *stomach* contracts, both in its longitudinal and transverse diameter when the electrodes are moved carefully from position to position, so as to include the stomach between them, in different directions, and so that the current passes through it, or, at least, so that its neighboring sentient nerves may bring about a reflex action on the viscus that *tones it up.* When examined under the action of the current in a mutilated animal, the movements of the stomach are invariably seen to be from the cardia to the pylorus — i. e., downwards.

If we directly Faradaize the *salivary glands*, we do not obtain a flow of saliva. Professor Claude Bernard has demonstrated † that if we Faradaize the *lingual* and the *auriculo-temporal* nerves, the *chorda tympani*, and the posterior parotid branches of the *facial* nerve, then there is an abundant flow of saliva. This he explains as being the result of the enlarged blood vessels produced by the electricity; that this dilatation of the vessels is

* Preliminary Proceedings of the Royal Society, London, Vol. IX., No. 32.

† Journal de la Physiologie de l'Homme, Paris, 1858, p. 649.

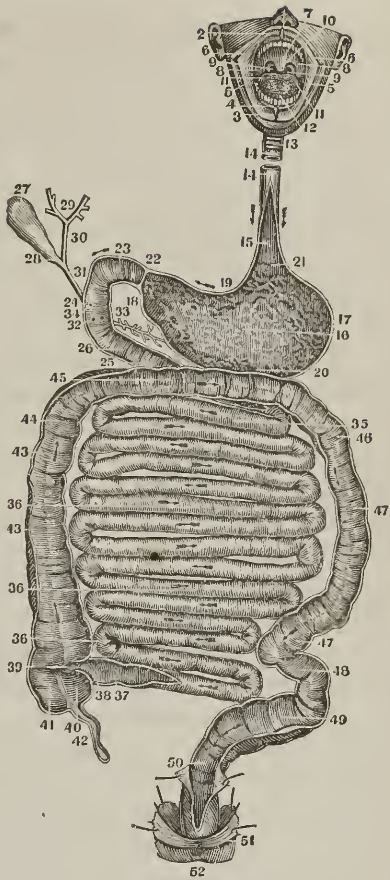


Fig. 61. A View of the Organs of Digestion. By being cut through their median line in nearly their whole length, it shows their mucous or *internal* surface and arrangement. A portion of the Œsophagus has been removed, for want of space to show the Figure. The Arrows merely show the course substances naturally take along this "*Alimentary Canal.*"

1. The Upper Lip.
2. Its Frœnum.
3. The Lower Lip, turned down.
4. Its Frœnum.

5, 5. Inside of the Cheeks, covered by the Mucous Membrane.

6. Points to the Opening of the Ducts of Sterno.
7. Roof of the Mouth.
8. Lateral Half Arches each side of the Palate.
9. Points to the Tonsils.
10. Velum Pendulum Palati.
11. Surface of the Tongue.
12. Papillæ near its Point.
13. A Portion of the Trachea.
14. The Œsophagus.
15. Its Internal Surface.
16. Inside of the Stomach.
17. Its greater Part, called the Great Cul de Sac.
18. Its lesser Part or Extremity.
19. Its lesser Curvature.
20. Its greater Curvature.
21. The Cardiac Orifice.
22. The Pyloric Orifice.
23. Upper Portion of the Duodenum.

24, 25. The remainder of the Duodenum.

26. Its Valvulæ Conniventes.
27. The Gall Bladder.
28. The Cystic Duct.
29. Division of Hepatic Ducts in the Liver.
30. Hepatic Duct.
31. Ductus Communis Choledochus.
32. Its opening into the Duodenum.
33. Pancreatic Duct.
34. Its opening into the Duodenum.
35. Upper Part of Jejunum.
36. The Ilium.
37. Some of the Valvulæ Conniventes.
38. Lower Extremity of the Ilium.
39. Ileo-Colic Valve. [All before this point is for digestion and nourishment. All after this point is a *receptacle* for excrementitious matters.]

40, 41. Cœcum, or Caput Coli.

42. Appendicula Vermiformis.

43, 44. Ascending Portion of the Colon.

45. Transverse Portion of the Colon.

46, 47. Descending Portion of the Colon.

48. Sigmoid Flexure of the Colon.
49. Upper Portion of the Rectum.
50. Its lower Extremity.
51. Portion of the Levator Ani Muscle.
52. The Anus.

due to the attraction of greater quantities of arterial blood, that is always induced by the action of the current; and that the excretion of the saliva is effected by the same forces which attract the blood to the glands, and not by the tissue of the glands themselves, since the elementary substance of the salivary glands has no inherent contractile power. But if the above nerves are excited, according to Professor Bernard, the amount of saliva which may be gathered in a very little time from the salivary glands will be found to far exceed the volume of the entire glands themselves, so that it cannot be shown that the saliva is simply squeezed out of the gland. It is thus proved that the secretion occurs in the salivary glands at the very moment when the electric current is made to traverse these nerves of secretión. If the sympathetic nerve is traversed by the current, neither the normal nor abnormal secretion is then induced, but, on the contrary, all salivary secretion is arrested.

When the abdomen of a recently-killed animal is quickly opened and exposed to the air, particularly if a cool air is blowing over it, the small intestines are seen to contract, dilate, and move, from the contact with the air. But very soon these contractions cease. If, now, the poles of an electro-magnetic current be brought in contact with any portion of the intestines, — say on the ilium, — they will renew the contractions, and urge the contents of the canal towards their receptacle, the rectum. But observe: if the electrodes are applied near each other, — say on some portion of the duodenum, and retained there for a minute, and are then very quickly withdrawn from it, — the contraction that has been thus induced at that place continues, and *increasing* for a little time after the electrodes are removed, then moderately disappearing. The stomach is more quickly and strongly responsive to the electric stimulus than the duodenum. This latter is rather more so than the small intestines, and they are more so than the colon and rectum. But the *sphincter-ani* is more prompt and powerful in its response than any portion of the alimentary canal, while the *cæcum* appears to be the least so. The *ductus choledochus* and the liver contract notably under the influence of the electric current. If the elec-

trodes are applied on either side of the gall bladder of a mutilated living animal, it is seen to contract slowly but extremely, so much so that the contraction actually divides the gall bladder into two sacs or compartments, that are complete, while the great portion of the bile is quickly expelled into the duodenum. But whether the *pancreas* and *spleen* contract in the human organism, under this influence, is not so clearly determined; for while the earlier observers who employed constant voltaic currents, as Kölliker, Gerlach, and Dittrich, obtained negative evidence, Harless, Claude Bernard, and Wagner testify that they have seen contractions in the fibre-cells of these organs.

The *ureters*, the *urinary bladder*, the *uterus*, and *tunica vaginalis*, the *vas deferens*, and the *epididymis*, contract, some powerfully and others less so, but all more or less decidedly, under the electric current; and these contractions continue for a little time after the electrodes are removed. Dr. Weber early noticed at least partial contractions of the uterus in the living bitch, and other animals. But very recently we learn that Dr. Mackenzie, of England, read a paper before the Royal Medical and Chirurgical Society, showing his experience in the use of galvanism as to its action upon the contractile structure of the uterus, and its remedial powers in obstetric practice.* He first instituted some experiments upon the gravid uterus in the lower animals, the organ being exposed so that the exact influence of the electric current was seen. Thus it was shown that the electricity produced a peculiar and very remarkable influence upon the fibres of the uterus, and this was most notable when the electro-magnetic current was directed in a longitudinal direction — i. e., through the uterus from the upper portion of the spinal cord, the current running downwards, in a continuous manner, to the lower portions of the abdomen, or, better still, to the cervix uteri, or to the vulva. He found the local or direct application of both the electrodes to the uterus less effectual, even in that direction, and less still if applied transversely or obliquely; for in these two latter conditions, the contractions were local and partial,

* Braithewaite's Retrospect, Part XXXVII., p. 271.

being confined to a line directly between the placing on of the two poles. He found that single shocks produced no influence upon it. Guided by these results, Dr. Mackenzie has employed electric currents, in several very critical cases in obstetric practice, with remarkable success.

Effects of Electric Currents on the Heart and Blood Vessels.

If we examine the heart of an animal immediately after death, as soon as the heart has ceased to beat, we see that the electro-magnetic current brings back the rhythmatic contractions. But the phenomena produced by applying the electric stimulus *directly* to the heart differ according to the part of the heart so touched. The contractions are uniformly more marked in the right than in the left ventricle; for after death, the left ventricle is usually found firmly contracted upon itself, and is more insensible to the stimulus. But the right ventricle is almost always surcharged with blood, and this contracts very beautifully when touched with the electrodes. If the animal is killed by chloroform, then sometimes the left ventricle is observed to be still continuing to pulsate a very little, while the right ventricle is entirely still, and largely distended with black blood. It is found that if the *right ventricle* be electrized in these cases, its contents are expelled, and its rhythmatic pulsations are soon restored and established.

We said that different phenomena are observed from touching different points of the heart. If we are reminded, however, that the heart is animated with two peculiar sets of nerves, we at once comprehend the wide difference in the effects. The heart's nerves are, first, the *ganglionic*, and, second, the *vagi*. The ganglionic or sympathetic *is its motor*, and the *vagi is its regulator*. If the former is electrized, the contractions of the heart are *augmented;* if the latter is thus acted upon strongly, then the pulsations of the heart *stop*. Besides the above facts, first observed by Professor Weber, of Leipsic, there are very many other instructive results obtained from electrizing the *vagi*, which were, indeed, mostly discovered by M. Claude Bernard. He found,

by applying rather strong electro-magnetic currents to the two nerves vagi, on either side of the neck, that not only does the heart lessen its action, or totally cease action, but that respiration also stopped, and that the eyeballs were greatly protruded from their sockets. From this he inferred that there is at the same time an action of the *vagi*, both upwards and downwards; i. e., to the central organs, and to the viscera of the thorax. If the vagi be cut across and let alone, the actions of the heart rapidly increase, until they run wild, so that the number or frequency of the pulsations *cannot be counted.* We therefore know that the vagi is the *regulator*, and not the motor of the heart; and further, when very quick pulsations of the heart are occurring, we know that the vagi is paralyzed, or approaching a state of paralysis; or else the sympathetic nerve is conveying from the nerve centres some increased *abnormal* stimulus.

Faradaizing the nerves *vagi*, *actively*, *while intact*, we get the cessation of the heart's action, and also that of respiration; and the eyes greatly protrude. But if we cut the vagi across, as can be done in the living dog, and then apply the electric stimulus to the lower cut end of the nerve, it does not stop the respiratory motions, as might be expected, but it does effectually put a stop to the pulsations of the heart and arteries; and, moreover, it usually causes vomiting. But if the upper end of the cut nerve be electrized by the same current of electricity, no effect whatever is produced upon the movements of the heart, nor yet is the respiration disturbed, provided the current is a moderate one; *but if a stronger current be employed*, we then see that respiration is suspended, and that always during inspiration; that the blood in the carotid arteries becomes black; that there is a passive injection of a dark color, of the membranes of the mouth, throat, nose, and eyes, from the asphyxia; and yet the carotid arteries continue to pulsate. If this is not carried too far, and the electrizing is discontinued, the respiration is gradually restored, and finally their force and frequency become greater than before the electric stimulus was first applied. M. Bernard also found that, under these circumstances, the blood, the cerebro-spinal fluid, and the bile, all contained sugar; that the secretion

of urine is suspended, and at the same time there is an excessive flow of saliva. It is, therefore, fairly concluded, that the *vagi* do not form the motory system of the heart, but that they rather regulate the rhythmatic heart actions, which themselves are caused only by the sympathetic fibres. The aorta, large arteries and veins, and the smaller blood vessels are very differently affected by the electric current, and that in proportion to their structure and their attending nerves. Probably the aorta in man does not contract under its influence; but this is accounted for, when we recollect that the aorta is mostly made up of *elastic fibres*, while there are very few contractile fibre-cells. These latter are supposed to be so few, and so deficient in power, even when excited by electricity, that they are not able to overcome the elastic forces which constantly tend to retain the aorta open. This is true of man, but not so as regards the aorta of the horse, ox, or sheep; for here we find the aorta contains a very much larger proportion of the contractile fibre-cells than is found in the aorta of man. But in the human organism we find, again, that in the smaller blood vessels, and particularly in the smaller arteries, *the contractile fibre-cells largely predominate* in their structure; and this accounts for their strong contractions under the influence of the electric current. True to the *nature* of their contractile fibre-cells, they are moderate in beginning to contract, and that only after the action of the current for some appreciable time; and even sometimes after the electrodes are taken away are they seen to continue to increase their contractions to their maximum, and then as deliberately take on their normal state; which is so unlike the phenomena of electro-muscular contraction, on the one hand, and yet, on the other, as unlike the negative action of tissues that are composed simply of elastic fibres.

The action of electricity on the blood is mainly *chemical;* and therefore we might expect that *Galvanic* currents would have more effect than Faradaic, or than frictional electricity; and so it is. If we use galvanic electricity, we are able to coagulate fresh blood, taken either from an artery, vein, or capillary; and this can be done, moreover, where the blood is flowing in the vessels of the living body. If we act upon *arterial* blood by a

powerful current, a very firm clot is formed, which adheres to the walls of the artery, and so stops the circulation. This can be accomplished, in like manner, in the *veins*, but in less degree. If a current of moderate intensity is used, the clot forms in from five to fifteen minutes. The clot forms *only at the positive pole*, because of the decomposition of the salts of the blood, and the liberation of acid at that pole; while, at the *negative pole*, the action and decomposition there sets free an *alkali*, which renders the blood even more fluid than natural. "If the positive electrode of a moderately active galvanic battery is plunged into the artery of a living dog, the blood soon becomes coagulated, and that without pain, inflammation, or gangrene; but if the *negative* electrode is thrust into the artery, there is *no* coagulation, but rather the blood is rendered *more fluid*, with pain, inflammation, and sometimes speedy gangrene. Hence, whenever we wish to coagulate the blood in the vessels, as for varicose veins, or in an aneurismal sac, we must employ the *positive pole* in the sac or vessel, while the negative is simply a large moist surface contact, and so directed to the border of the sac, or vessel, that the current shall pass *directly* and *steadily through it*."

When galvanism is applied to blood vessels, they are found to contract pretty generally; but this appears to be much in proportion to the number of fibre-cells they respectively contain. Thus the aorta in man scarcely contracts under this influence, because it is mostly made up of elastic fibres, and with but very few contractile fibre-cells. But these fibre-cells are found far more uniform and abundant in the smaller arteries, and consequently *they* are seen to contract energetically, when thus influenced. They have a peculiarity of contraction, and that is, as repeatedly observed, only *after the current has been acting for a little time*, *and which effect also continues for a little time after the current is discontinued*.

Professor Claude Bernard assumes that the capillaries possess two properties,—the one for contraction, the other for dilatation,—and that either of these are brought into their physiological action under the influence of a peculiar set of nerves.

From most reliable researches, then, it is fairly demonstrated, that *the circulation of the blood through the smaller vessels and capillaries can be controlled by moderate electric currents artificially applied;* and hence the very natural inference, that the ordinary native or animal electric currents, which always exist in the living and healthy human body, are as constantly influencing the circulation of the blood. By such means the blood circulation may be deranged; so also may the various secretions *from the blood* be influenced. The diseases, alterations, or deviations of the blood are arranged by Dr. Simon in four classes, viz.: —

The first is where the fat and fibrine are increased, while the corpuscules are diminished; as observed, for instance, in acute and severe inflammations of serous tissues, and as in acute rheumatism.

In the second class the corpuscules are increased, while the fibrine is diminished, as in typhus, small pox, and cerebral hemorrhage.

The third class comprises those cases or conditions in which both the fibrine and corpuscules are below par, and decidedly deficient, while the water of the blood is increased ; as observed, for instance, in anemia, carcinoma, scrofula, chlorosis, and the true cholera.

The fourth class embraces those in which new matters are contained in the blood ; as, for instance, in Bright's disease of the kidneys, and in all cases of chronic rheumatism, or wherever bile, or urea, or any other substance poisons the blood. Occasionally fat, and under certain circumstances a great variety of minute particles of other matters, may be observed in the human blood, by the aid of a good microscope. Therefore we know that the blood may be actually altered in material and quality, and therefore *may* sensibly change the working of a part, or of the whole of the electro-nervous batteries of that individual organism. And conditions which are so manifestly electro-nervo-pathological, as well as humoral, are known to be, in part at least, *corrected* by means of iron, quinine, phosphorus, and sulphur ; or by farinaceous or animal food, exer-

cise, sunlight, and air; while very many others are *not quite reached* by any or all these rational, but, for the given case, insufficient means, until reënforced by the coöperating, and vitalizing in-workings of correctly employed currents of electricity. Moreover, in studying the minute relations of acute and chronic nervous diseases and derangements, we find presented to our notice several points of departure: —

First, we may find the general muscular and nervous electric circuit, also called "animal electricity," acting fiercely, irregularly, or perhaps very languidly; and either of these, *from the peculiar condition of the blood*, which in the one case renders it *a too exciting fluid*, for the health of that living galvanic-like organism; or, in another case, it is too feeble, or too much poisoned, perhaps, to act with any degree of efficiency; or we may have actual disease of the cord, and brain, and ganglia parenchyma; or of the peripheral parenchyma, and its media, (nerves,) which serve as conductors or telegraphs to connect the outer stations of minute vitalized voltaic batteries with the great cervical ganglia and brain. Besides, we must bear in mind the natural nervo-electric relations of nutrition, growth, and repair, as well as the *abnormal* products, or deposits, occasionally produced simultaneously with the deviations from the usual standard of actions as observed in health.

The essential character of inflammation is as little understood as fevers; and these two great classes of diseases are essentially different. The former is an abnormal action, tending to the formation of pus. Now pus is an organic cell; which, however, is very different from the ordinary ultimate cells, of which the various parts of the organism is constructed. When inflammation occurs, we have some greater or less deviation of the ordinary sensations, increase of temperature, and great vascularity. In fever, we have that sort of almost total absence of motion, which is termed "prostration." But this is not in any sense paralysis. The feelings are, for the time, unbalanced, perverted, and morbid. Certainly, all this goes to show the extensive implications of the electro-nervous system and apparatus in these universal diseases. In actually developed phthisis, and

scrofula, we see the greatest deviation of normal cell-life, while there is but very little nervous phenomena. In these maladies we find extensive *organic* disease, yet little pain, little impairment of motion or of sensation, when compared with the same amount of change in the *electro-nervous affections*, as, for instance, rheumatism. Cancer, like scrofula and inflammation, consists of *abnormal* organic cell; which, however, differs from both tubercle and pus in its physical character. Syphilis is also a malady of abnormal organic cell; the *virus* of which influences the entire cell-life of all that individual organism. Now, all these and other organic diseases appear to me, to *proscribe* any sort of use of, or hope from the use of any form of electricity employed as a therapeutic agent.

Professor Bennet, of Edinburgh, says, "Every known fact convinces me, — and the progress of science only adds strength to my convictions,— that we must ascribe the ultimate *cause* of inflammation to a degenerate state, arising *from a derangement of those forces* which regulate the nutritive powers of the living economy," and that the only correct definition of inflammation itself is, "an exudation of the normal *liquor sanguinis*." It is in vain that physiologists seek in the alterations of the vessels on the one hand, or in the morbid changes in the blood on the other, for the primary cause of this important condition. Facts prove that both are more or less affected; and they also show that neither the one change nor the other, nor yet the two combined, constitute inflammation. The vital *nervo*-electric properties of the tissues (understanding by these the little known and less defined conditions necessary for carrying on the nutritive process) are in all such cases *deranged;* and such alteration is the very *cause* of the changes which have been referred to, and not the effect.

The increased heat manifested after certain manipulations with electric currents on the living skin and flesh is not simply due to a greater afflux of blood to the vessels of the part so treated; for it is proved, that these are *not expanded* by *electro-magnetic* currents, certainly, if applied directly over the muscles, but are then rather constricted for the time, and therefore

contain less blood than normal, and yet there is more heat. Hence, if the heat does not arise from an action on the skin, nor yet from the influx of blood and fluids, it must be due to an augmentation of those nervo-electro-chemical changes which we call *vital chemistry*, and which are continually going on in all the tissues of the living organism, but more particularly in the *muscles*, and which action constitutes their very existence, growth, and life, their wear and repair, or exhaustion and nutrition, much as if an engine were so arranged and endowed as to draw its own water and coal, clear its soot and ashes, oil its own axles, and do its own forging.

It is, then, well ascertained that the heat developed in living tissues after treatments by electro-muscular contractions, as more frequently noticed in the paralytic and atrophied, is an increased *vital* and *catalytical* action among the tissues and liquids, rather than a chemical action on the surface of the skin. This proposition is also fully confirmed by various pathological experience.

Two results are determined from the effects of electric currents on enfeebled, relaxed, or paralyzed muscles; and the first is, an *increase of heat*, and the second, an *increase in size*, of the parts so acted upon. The solid structure of muscle fibres *imbibes* a fluid from the blood, which is discovered to be, at times, variable in composition. If this muscular fluid is taken from a muscle that has been long at rest, it will be found to give a *neutral* reaction; but after labor or active electric excitation of the muscle, the fluid will then give an *acid* reaction, in consequence of an increased absorption of oxygen, and consequent oxidation and formation of carbonic acid. This can be proved by actual experiment, if we measure the quantity of oxygen absorbed, and carbonic acid exhaled, by the muscular substance of the frog's thighs which have been skinned and suspended in closed glass vessels filled with air or oxygen; for we find that if the muscles in some of the vessels are electrized, and the others not, the quantity of the gases absorbed and exhaled by the electrized muscles is found to be more than double that absorbed and exhaled during the same time by the quiescent muscles in the other vessels. From many fair trials, we know, at least, that

this difference occurs in the living muscles of man, and that by the augmentation of chemical changes, the heat of the part is sensibly increased. More blood is attracted to the capillary vessels, particularly those of the muscular substance whereby the bulk of the muscles is expanded and actually increased. The very fact that there is more blood attracted to these tissues produces, under this more lively induced action, an increased nutrition.

The human *brain*, we know, is composed of gray and white matter, in distinct layers, yet folded up in a wondrously compact manner, like a very economical voltaic battery. If the brain were unfolded and spread out, it would be seen to have the layer of *gray substance* placed first over its surface, while the *white* is inside, and this latter showing numerous glistening fibres, or conductors, converging towards a centre. In the composition of the brain, we know there is a large amount of phosphorus, combined with a profusion of arterial blood and oily matter; and is capable of a peculiar excitation, somewhat analogous to galvanic electricity. From analogy, says Dr. O'Reilly, of New York, it would appear, in fact, that the arrangement of voltaic or galvanic pairs, in a battery for yielding large quantities of electricity, was founded on the very same principles that here exist; and this appears to be borne out to a certain extent by facts. When a man long overworks his brain, phosphorus is found in the urine, while the nervous energy and endurance are diminished. A tranquil sleep or a longer rest is required to allow the process of recuperation, and the aid of electricity helps the repairing process. It is a further remarkable fact that whereas the *gray* substance is placed on the *external* surface of the convolutions of the brain, in the spinal marrow it is located *internally*. Equally worthy of notice is it, that the current of the *immaterial* agent in the brain is *from* the surface towards the centre and base, whilst in the spinal cord, mark, it is from within *to* the surface. In both cases, however, the arrangement is in accordance with the origin of the roots of the nerves, as they are found situated in the brain and in the spinal cord. The conclusion, from these premises, says the doctor, would be evidence that the phosphorus acts on the gray substance, so as to produce the *immaterial* current or nerve agent, in a similar way as the oxygen unites with the tissues and the minute and pervading organic nerves, in the maintenance of *heat*, and that *immaterial* agent termed *life*. In fact we know that "animal electricity" and "nerve force," though not precisely identical, are most intricately connected. We know that *by electric excitation we can produce an increase of bulk and heat in the living tissues, or a return of these where deficient. A strong direct primary current, occasionally quickly reversed, through contiguous electrodes*, is the best for this end; it can also be accomplished by secondary currents.

Giddiness is usually caused by a deficient supply of blood to

the head. Exhaustion of nervous energy will likewise produce it. Cold will produce it. So will suddenly changed currents of galvanism. This, then, it is highly probable, is an electro-physiological phenomenon. Insensibility arises from the same causes that produce giddiness, but it requires a greater degree. In giddiness, the nerve batteries of the brain appear to be disturbed or unbalanced; but where there is insensibility they seem almost suspended to the last degree. The blood to the brain is deficient or deteriorated, and unfit for the purpose, so that the sensorium nerve-battery cannot act. No impression can be received or responded to, when the blood is vitiated *to a certain degree*, as by carbonic acid, chloroform, narcotics, or poisons. It is, perhaps, scarcely necessary to say that this may occur from an organic lesion somewhere between the centre and periphery. Now, if these occur with a state of atony, the iron preparations, with nutritious food, are the best means for restoring the usual constituents of the blood. If in the *strumous* patient, cod-liver oil will the better reëstablish the peripheric portion of the electro-nervous arrangement. In all cases, a judicious employment of *electricity*, *in connection with* these other rational means, can be a powerful auxiliary.

Effects of Electric Currents on the Muscles respectively.

If we electrize the muscles of the face of a person just dead, and while the muscles have retained their natural excitability, we can truly study the mechanism of physiognomical expressions, because we can thus excite each muscle, and cause it to contract much the same as when they are put under the action of thoughts, passions, habits, or *prevalence* of character. The muscles are inclined to retain, during their repose, some degree of the predominance of tonic force exercised most repeatedly and constantly upon them, and this etches or carves in every human face its own peculiar expression and character, which we term physiognomy. Dr. Duchenne has made *this* subject his very special study, and from him we obtain many highly interesting facts.

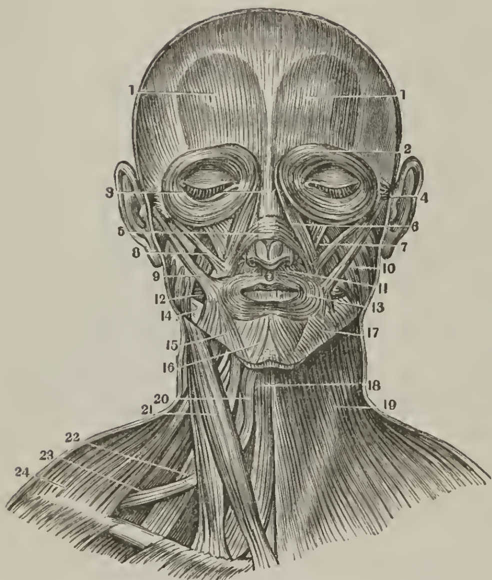


Fig. 62. Muscles of the Face and Neck.

1. Anterior Bellies of the Occipito-Frontalis.
2. Orbicularis, or Sphincter Palpebrarum.
3. Nasal Slip of Occipito-Frontalis.
4. Anterior Auriculæ.
5. Compressor Naris.
6. Levator Labii Superioris Alæque Nasi.
7. Levator Anguli Oris.
8. Zygomaticus Minor.
9. Zygomaticus Major.
10. Masseter.
11. Depressor Labii Superioris Alæque Nasi.
12. Buccinator.
13. Orbicularis Oris.
14. The denuded surface of the Inferior Maxillary Bone.
15. Depressor Anguli Oris.
16. Depressor Labii Inferioris.
17. The Portion of the Platysma-Myoides that passes on to the Mouth.
18. Sterno-Hyoideus.
19. Platysma-Myoides. It is wanting on the other side of the Figure.
20. Superior Belly of the Omo-Hyoideus near its insertion.
21. Sterno-Cleido-Mastoideus.
22. Scalenus Medius.
23. Inferior Belly of Omo-Hyoid.
24. Cervical Portion of the Trapezius.

When the muscle *frontalis* is slightly contracted, the face cheers up; then, when more contracted, its expression is changed to surprise, and then even to doubt; if in the highest degree of contraction, and assisted by other muscles, it produces the agreeable surprise, and so on to terror. This muscle wrinkles the forehead; therefore, when it is paralyzed, the wrinkles cannot be produced. The *paramidalis nasi*, which is but a nasal elongation of the frontalis, acts, however, as the antagonistic of the frontalis, and when contracted, therefore, gives the expression of sadness; when more contracted, a threatening aspect. When the *orbicularis palpebrarum* and *corrugator supercilii* are both contracted, there is produced the expression of reflection and perplexity; and when aided by the pyramidalis, there is the expression of malice. We see that the *platysma myoides* gives the expression of pain; and when united with the frontal muscle, it expresses terror; if with the pyramidalis, then there is rage.

The electro-contraction of the *triangularis nasi* gives the voluptuous expression; while that of the *zygomaticus major* always yields those expressions of mirth from the slightest twinkle of a roguish smile to the most extravagant laugh; and if this is united with the frontalis, there is then a modification to the agreeable surprise; but if with the *platysma myoides*, there is the restrained, "can't-help-it" or threatening laughter. The contraction of the *zygomaticus minor*, on the contrary, gives the melancholy air to the countenance; and the *levator alaque nasi*, with the *labii superioris*, are the crying muscles, that in children produce such an ugly grimace. The *levator menti* is the only muscle in action when one mutters or repeats in audible prayers, as is done in Roman Catholic churches. It is by the contraction of the external fibres of the *orbicularis oris* that the lips are protruded, as for pouting, kissing, and whistling; while the internal fibres press the lips against the teeth. Then the contraction of the *triangularis oris* gives the deeper expressions of sadness. In children it is seen in play as the precursor of tears; but in its maximum of action there is presented the striking expression of disgust.

The *trapezius* arises from the inner third of the occiput, and is attached to the last cervical and whole of the dorsal vertebræ, also to the scapula, with clavicular attachment from occiput to clavicle. It exercises action upon the shoulder in *three directions;* for its clavicular and occipital fibres draw the shoulder upward; its upper dorsal, cervical, and scapular fibres draw it backward, i. e., to the spine; its dorsal fibres draw it a little downward. If, then, the *inferior* portion of the *trapezius* be Faradaized, the base of the scapula is drawn backward, and its inferior angle downward. If the *middle* portion be thus excited, the scapula is elevated, and its inferior angle is drawn farther from the spine. If the *clavicular* portion of this muscle be Faradaized, then the head is drawn towards the side acted upon by the current, and besides, it is drawn slightly backward, so that the chin is turned a little towards the opposite side, and the clavicle is also elevated by it. The clavicular portion of the trapezius is exceedingly responsive by electric contractions, because it is animated by a double set of nerve fibrils, and that is, both from the spinal accessory and from the cervical plexus. Therefore unusual care is required to proceed here with the currents in moderation and gentleness at first. If we apply the electric stimulus to the clavicular portions of both trapezius muscles, i. e., by directing one electrode to each at the same time,—the head is drawn directly backward.

The *latissimus dorsi* arises from the spinous processes of the lower dorsal and of all the lumbar vertebræ, also from the sacrum, ilium, and four lower ribs, and is inserted into the bicipital grooves of the humerus. Hence the action of this great muscle tends to draw the shoulder back upon the spine, *or the spine laterally towards the shoulder.* It passes over the inferior angle of the scapula, and by pressing upon it, steadies it. If it is Faradaized, it draws the arm downward and backward; the scapula is at the same time approximated to the spine, but not elevated. The trapezius and the latissimus dorsi form the first and outer layer of the muscles of the back.

When the *deltoid* muscle is electrized, it *abducts* the humerus, but does not elevate it even in that direction above the horizontal

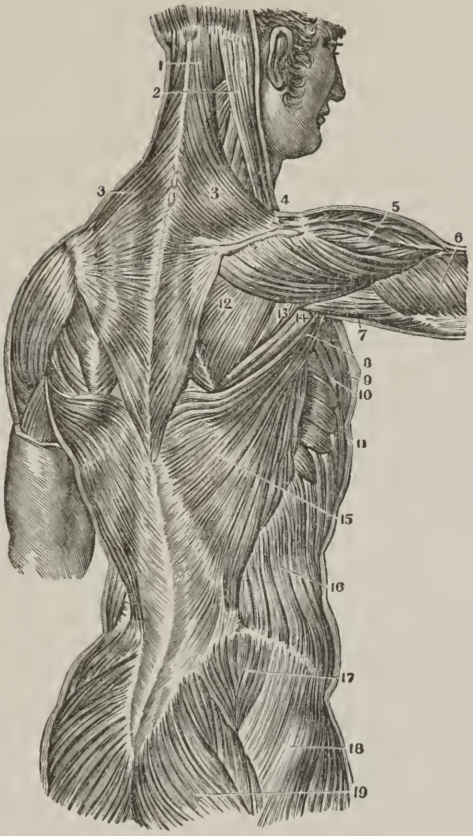


Fig. 63. A View of the Muscles of the Back; the first layer, as shown after the removal of the integuments that cover them.

1. Occipital Origin of the Trapezius.
2. Sterno-Cleido-Mastoideus.
3. Middle of the Trapezius.
4. Insertion of the Trapezius into the Spine of the Scapula.
5. Deltoid.
6. Second Head of the Triceps Extensor Cubiti.
7. Its superior Portion.
8. Scapular Portion of the Latissimus Dorsi.
9. Axillary Border of the Pectoralis Major.
10. Axillary Border of the Pectoralis Minor.
11. Serratus Major Anticus.
12. Infra-Spinatus.
13. Teres Minor.
14. Teres Major.
15. Middle of the Latissimus Dorsi.
16. External Oblique of the Abdomen.
17. Gluteus Medius.
18. Gluteus Minimus.
19. Gluteus Magnus.
20. Fascia Lumborum.

line, which will be verified by experience in this department of practice. It will be noticed that if only the anterior fibres of this muscle are touched by the current, the arm is started forward and inward, and carried to an elevated posture. But if directed only to the posterior fibres, then the humerus is started backward, and if the current be pretty strong, the hand will also be carried back, and even raised, and retained high up the back. When aided by the *serratus magnus*, the deltoid not only lifts, but sustains, the arm elevated; and when aided also by the joint action of the middle portion of the trapezius, it, — or rather they, — elevate the arm to the head, and to all postures above the horizontal line of the shoulder. The deltoid is exceedingly prone to pains and palsy, and occasionally suffers from atrophy.

The *rhomboideus major* arises from the spinous processes of the four upper dorsal vertebræ, and is inserted into the posterior border of the scapula. Its action is to draw the scapula horizontally back upon the spine, and the spine laterally to the scapula. The *rhomboid minor* arises from the last cervical vertebra, and is inserted into the edge of the triangular surface of the posterior border of the scapula. The action of this muscle is to draw the scapula obliquely upward, — i. e., towards its cervical origin; and these two muscles especially influence the dorsal "*curvature*" of the spine. But there is the *levator anguli scapulæ* also, that goes to make up the second layer of muscles on the shoulders and back, which arises from the transverse processes of the four upper cervical, and is inserted into the upper angle and posterior border of the scapula. The action of this muscle is to draw the scapula upward towards this cervical region, and the spinal column of that region downward towards the scapula. If, then, the *rhomboid* be electrized, as where the *trapezius* is destroyed by palsy or atrophy, the scapula is raised and also rotated on its axis, so that the inferior angle is nearly in the same line with the external angle; and by the tonic contractility of this muscle, it fixes the base of the scapula firmly against the walls of the thorax. If the *rhomboid* is also atrophied or palsied, then the base of the scapula projects from the thorax, and becomes very prominent under the skin, so that a remarkable cavity is formed between it and the spine.

The *serratus magnus* is mainly an inspiratory muscle, because it acts in concert with other muscles, to elevate the ribs; from which, indeed, it arises. It also contributes to lift the *humerus*. But the *serratus posticus inferior* is attached to the spinous process of the two lower dorsal, and the two upper lumbar vertebræ, and is then inserted into the angles of the four lower ribs. The action of all these muscle fibres is for depressing the ribs, and concurs in expiration, and at the same time slightly aiding a slight rotation of the ribs upon the vertebræ. The *serratus posticus superior* arises from the upper dorsal and one lower cervical vertebræ, and is then inserted into the margin of the second, third, fourth, and fifth ribs. Its action is directly antagonistic to the *serratus inferior*, for it tends to raise the ribs upon the spine, and so elevate the chest as to concur in inspiration. If it is permanently contracted, it would produce *dorso-lumbar curvature* of the spine towards that side; if paralyzed, the curvature would be towards the other side. The serratus magnus, being a broad, flat muscle, arising from the first eight or nine ribs by digitations, and inserted into the spinal border of the scapula, when normal, sustains the scapula forward, and contributes to keep up its external angle against the weight of the upper arm, which is so continually tending to depress the external angle of the scapula. We see, then, that the *trapezius* and the *serratus* are both opposed to this depression. But if the trapezius is paralyzed, or atrophied, or but fatigued and relaxed, then the external angle of the scapula is allowed to fall, more or less, while its inferior angle rotates upward and backward, so as to approach or override the spinous processes. And if the serratus magnus be also involved, as in a wasting palsy, then the external angle becomes even more depressed, while the inferior angle rises quite to the level of the external angle, and projects or hangs off hideously from the ribs.

The *splenius colli* and *splenius capitis* are two muscles that have a common origin at the six upper dorsal and last cervical spinous processes; then, again dividing, the latter goes to be inserted in the mastoid process of the temporal bone. They act

conjointly with their fellows, the antagonizers on the opposite side, in staying the head erect; and they also rotate the head. These muscles are liable to paralysis on one side, and perhaps simultaneous contraction on the other. The electric excitement can well develop their physiological action.

The *sacro-lumbalis* takes its origin from the sacrum, ilium, and lumbar vertebræ, and is inserted into the angles of the six lower ribs. We must be aware, that its action is to keep the lumbar vertebræ *erect*. If its fellow on the opposite side is weakened, relaxed, or paralyzed, it will contract, or *vice versa*, and thus constitute a "*persistent lumbar curvature*."

The *longissimus dorsi* also arises from the sacrum and lumbar vertebræ, and is radiated so as to be inserted into the angles of eleven ribs, and the transverse processes of all the dorsal and lumbar vertebræ. This muscle, too, is to be reached by the electric stimulus. If it is unbalanced with its antagonizer, it contributes to a "*lumbar curvature*" of the spine. Therefore we can say, not empirically, but rationally, that "spinal curvatures" from these causes, or complicated with these muscle deviations, can be cured by electric currents, or, *at least*, *aided in their cure*.

The electro-muscular contraction *test*, thus aids us in determining the *exact* physiological action of all the muscles of the back, (which are liable to be not only neuralgic or rheumatic, but also enfeebled, relaxed, palsied, and even *atrophied*, and hence, also, involved in many spinal curvatures, and other affections,) but perhaps not so familiar to the profession generally. They can be summed up thus: —

1. In the *cervical region* we find that the grand normal action of the *trapezius* is to draw the cervical spine towards the shoulder, and the shoulder towards the cervical portion of the spine. The *levator anguli scapulæ* lifts the scapula towards the head, and draws the head over laterally towards the back shoulder. The *rhomboideus minor* draws the scapula upward and backward to the spine, and the spine towards the scapula. The *splenius capitis* draws the head over obliquely, i. e., laterally and posteriorly. The *splenius colli* draws the cervical vertebræ off

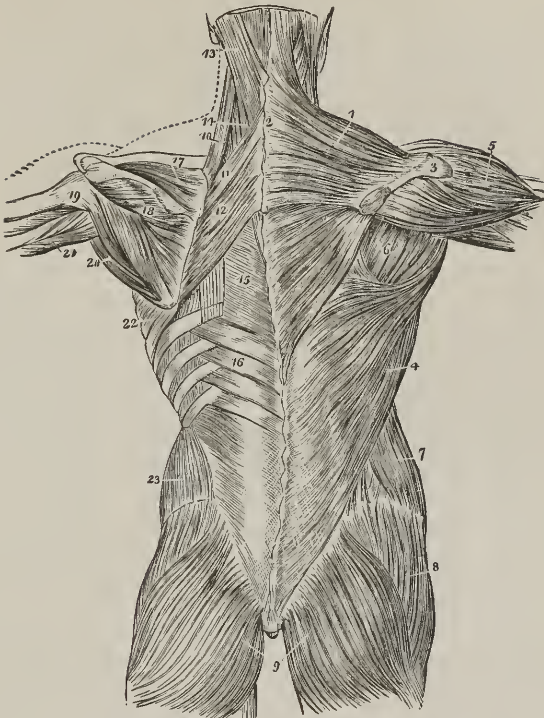


Fig. 64. A View of the second layer of the Muscles of the Back.

1. Trapezius.
2. A Portion of the tendinous ellipse formed by the Trapezius.
3. Spine of the Scapula.
4. Latissimus Dorsi.
5. Deltoid.
6. Infra Spinatus and Teres Minor.
7. External Oblique of the Abdomen.
8. Gluteus Medius.
9. Gluteus Magnus of each side.
10. Levator Scapulæ.
11. Rhomboideus Minor.
12. Rhomboideus Major.
13. Splenius Capitis.
14. Splenius Colli.
15. A Portion of the Origin of the Latissimus Dorsi.
16. Serratus Inferior Posticus.
17. Supra Spinatus.
18. Infra Spinatus.
19. Teres Minor.
20. Teres Major.
21. Long Head of the Triceps Extensor Cubiti.
22. Serratus Major Anticus.
23. Internal Oblique of the Abdomen.

laterally. The *sacro-lumbalis* aids to raise the ribs upon the cervical vertebræ, and also draws the cervical vertebræ obliquely downwards. The *serratus posticus superior* lifts the ribs upward upon the spine, and draws the ribs firmly against the spine. The *cervicis transversalis* and the *complexus* help in sustaining the head and neck erect. The *tracelo-mastoideus* draws the head sidewise, and draws the cervical spine towards the side of the head. The *semi-spinalis colli* aids in a powerful perpendicular traction against the cervical vertebræ.

2. In the *dorsal region* we find that the *trapezius* draws the scapula almost horizontally towards the spine, and the spine towards the scapula. The *latissimus dorsi* draws the shoulder towards the dorsal vertebræ, likewise that portion of the spine towards the shoulder. The *rhomboideus major* here draws the scapula horizontally towards the vertebræ, and the spine to the scapula. The *serratus posticus superior* simply lifts the ribs upon the spine, and the *serratus posticus inferior* depresses the ribs. The *longissimus dorsi* creates an oblique action in the whole dorsal portion of the spine, which is lateral and posterior. The *spinalis dorsi* holds the spine perpendicularly erect posteriorly. The *tracelo-mastoideus* draws the cervical vertebræ obliquely. The *complexus* draws the head backward, sets it firmly, and holds it erect. The *splenius capitis* draws the head towards the dorsal spine, and the dorsal towards the head.

3. In the *lumbar region*, we observe that the *latissimus dorsi* draws the shoulder down towards the lumbar region, and that portion of the spine to the shoulder. The *serratus posticus inferior* simply draws down the ribs. The *sacro-lumbalis* exerts a powerful oblique action in the whole of the lumbar, and in a part of the dorsal region. The *longissimus dorsi* exercises an oblique influence along the whole of the lumbar vertebræ.

4. In the *scapular region*, it is noticed that the *trapezius* draws the scapula upward and backward; that the *levator anguli scapulæ* lifts the scapula towards the cervical region, and draws the spine downward towards the scapula; that the *rhomboideus minor* draws the scapula towards the dorsal spine, and the spine to the scapula; that the *rhomboideus major*

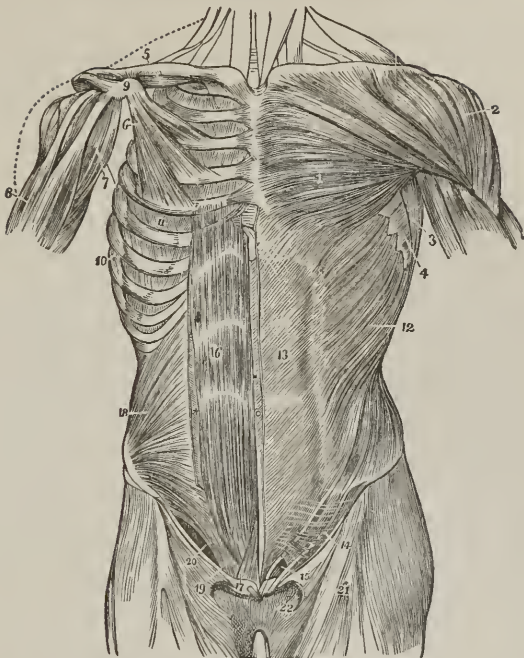


Fig. 65. Muscles of the Front of the Trunk. On the left side is a View of the Superficial Muscles; on the right side is a View of the Deep Muscles.

1. Pectoralis Major.
2. Deltoid.
3. Anterior Edge of the Latissimus Dorsi.
4. Serrated edge of Serratus Major Anticus.
5. Subclavius Muscle.
6. Pectoralis Minor.
7. Coraco-Brachialis.
8. Biceps Flexor Cubiti.
9. Coracoid Process of the Scapula.
10. Serratus Major Anticus, where the Obliquus Externus Abdominis has been removed.
11. External Intercostal Muscle of the Fifth Intercostal space.
12. External Oblique of the Abdomen.
13. Its Tendon. The Median Line is the Linia Alba.
14. The Portion of the Tendon of the External Oblique, called Poupart's Ligament.
15. External Abdominal Ring.
16. Rectus Abdominis.
17. Pyramidalis.
18. Internal Oblique of the Abdomen.
19. Common Tendon of the Internal Oblique and the Transversalis.
20. Crural Arch.
21. Fascia Lata Femoris.
22. Saphenous Opening.

draws the scapula horizontally to the dorsal spine, and that portion of the spine to the scapula.

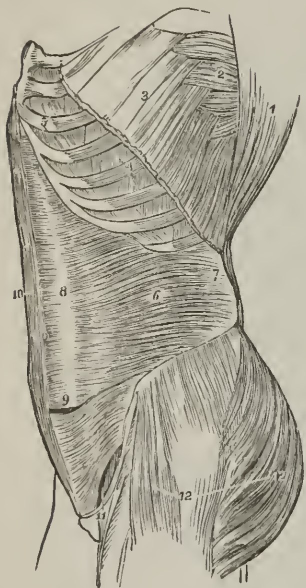


Fig. 66. Muscles of the Trunk, lateral view.

1. Latissimus Dorsi.
2. Serratus Major Anticus.
3. Upper Portion of the External Oblique.
4. Two of the External Intercostal Muscles.
5. Two of the Internal Intercostal Muscles.
6. Transversalis Abdominis.
7. Fascia Lumborum.
8. Part of the Sheath of the Rectus, and Aponeurosis of the Transversalis.
9. The Rectus Abdominis cut off, and in its Sheath.
10. Rectus Abdominis of the Right Side.
11. Crural Arch.
12. Gluteus Magnus, Medius, and Tensor Vaginæ Femoris, covered by the Fascia Lata.

5. In the *costal region*, it is observed that the *latissimus dorsi* tends, on the whole, to draw the dorsal spine into an oblique lateral position; that the *sacro-lumbalis* tends to hold the spine erect, and also make an oblique action in the lumbar vertebræ. The *serratus posticus superior* and the *cervicalis ascendens* tend to lift the ribs, and draw the cervical spine obliquely over and downward.

6. In the *abdominal region*, we see the *external oblique*, acting powerfully in the direction of its fibres, *from* the pubis *towards* the scapula; that the *rectus abdominis* acts perpendicularly in and near the anterior median line; that the *internal oblique* produces a deep together-drawing that radiates from the crest of the ilium, upward to the lower ribs, forward to the linia alba, forward and downward towards the pubis; and that this, together with the external oblique, acts most promptly and powerfully to the electric stimulus.

7. In the *pelvic region*, the *latissimus dorsi* is seen to draw the whole spine from the upper dorsal to the lower lumbar vertebræ, together with the ribs, in an oblique downward direction; and that the *longissimus dorsi* has a decided indirect action,

laterally, over both the dorsal and lumbar portions of the spine; while the *sacro-lumbalis*, acting from the broad edge of the pelvis as a fixed point, powerfully draws the body over laterally, as well as exerts a lateral effect on the whole lumbar region.

Effects of Electricity on the Fibre-cells in the Living Person.

Extensive researches have been made to determine the precise action or function of muscular fibre-cells, and the effects of electricity upon them. The action is peculiar. The distinguishing characteristic between the actions of animal muscular fibre, and organic contractile fibre-cells, when under the influence of electric currents, is, that the former respond *promptly*, while the latter respond *only after an interval, and that deliberately.*

This was ascertained by Dr. Nysten, during the first French Revolution, when the guillotine furnished him most ample opportunities for just such observations. More recently, Pro-

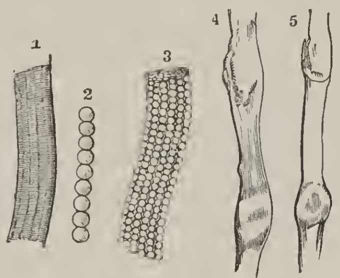


Fig. 67. Muscular Fibres — magnified 600 diameters.

1. Is a Muscular Fibre of *Animal Life* enclosed in its sheath of myolemma; this is a voluntary muscle fibre.
2. Is an Ultimate Fibril of the same, highly magnified.
3. A more highly magnified view of No. 1, showing the true nature of the Longitudinal *Striæ*, as well as the mode of arrangement and formation of the transverse *Striæ*. The myolemma is so thin as to permit the ultimate fibrils of molecules to be seen through it.
4. Shows a Muscular Fibre of *organic life*, with two of its *nuclei*, taken from the muscular coat of the human urinary bladder, and magnified 600 diameters.
5. Shows again a Muscular Fibre of *organic life*, from the muscular coat of the stomach, magnified the same.

fessors Kölliker, Gerlach, Henle, Harless, and others in Germany, mainly confirmed his conclusions; but like nearly all early electro-physiological investigations, the results obtained on this point did not exactly agree, because each experimented with a different kind of current, and hence each came to modified conclusions. But we can sum up the final and most reliable results in a very few words, viz.: —

The muscular fibre-cells respond more readily to an interrupted than to a continuous current, and hence *show more action* under induction currents than under continuous galvanic currents. If the latter is applied to them, however, there is a contraction at the closing of the circuit, during its continuance, and at its opening. The intensity and duration of the produced movements in the organic fibre-cells are determined by the intensity, interruptions, and duration of the current's action.

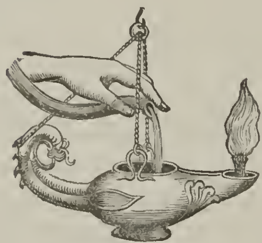
Furthermore, if an active electric shock, whether Static, Galvanic, or Faradaic, be applied to a voluntary muscle, it instantly contracts, and then as instantly relaxes. But, in contrast to this, the contractions produced in the fibre-cells by the electric stimulus are not simultaneous, or instantaneous with the closing of the circuit, but only *after* a little time, and while there is still action of the current upon the tissue; and this effect *lasts a little after* the cessation of the current. But the most remarkable phenomenon in regard to the movements of the fibre-cells as brought about by electricity, is, that they *occur only in an order which corresponds to their peculiar physiological purpose, wherever they properly belong*. Thus, if we moderately electrize the intestines, then only *peristaltic* movements are induced downwards; but never do we thus get movements from the rectum towards the mouth. If the ureters are Faradaized, the wavy movements are seen to be from the kidneys towards the bladder, but never in the opposite direction. Dr. Althaus says this will invariably occur, whatever may be the kind, intensity, or direction of the electric current, and whatever may be the point of the cell-fibre tract to which the electrodes are applied.

Œsophagus.

It is now known, from experimental demonstration and from results in practice, that electric currents here produce marked contractions, both in the longitudinal and circular fibres of the contractile fibre-cells, or of muscle fibres, or both. At least, such contractions are produced in the œsophagus, whatever be the nature of the structure that contracts. It is said that the œsophagus of most birds consists exclusively of fibre-cells; therefore we account for the motions produced by electricity in the throats of birds, beginning slowly, and lasting after the current is opened. But there are some birds, as the *rodentia*, or *gnawers*, such as the eagle, vulture, and parrot, whose œsophagus consists of animal muscle mainly, or only; and hence, when such are electrized, there are seen prompt and powerful contractions, and at the opening of the current there is as instantaneous dilatation. But this does not obtain so clearly in man, because in the human species, as in almost all mammalia, the œsophagus consists of *both* organic fibre-cells, and of animal muscular fibres. Hence, when the electric current touches the œsophagus directly or indirectly, the effects are both prompt and prolonged; i. e., they partake of the mixed phenomena arising from the contractile fibre-cells and from muscular fibre. If the action of the electric current be prolonged a little, or is made a little stronger, then the contractions are not limited to the throat only, but extend to the stomach.

CHAPTER V.

METHODS FOR THE MEDICAL EMPLOYMENT OF ELECTRICITY.



Alere flammam vitalem.

Precautions.

First of all, it is necessary to bear in mind that there is the greatest conceivable difference in individuals of the same age and sex as to their *susceptibility* to the effects of all electric currents; and these form *two classes* of patients. The first are those where there is *exalted sensibility*, and where only the most gentle procedure, and that with the most feeble currents, is at all admissible. In this class we may also include those with exquisite susceptibility to the *in-working* and also *reflex action* of the current, and that without their suffering, or even scarcely noticing it, during the *seance*. See pp. 475–479 & Notes in App.

The second class of persons are those where there is neither anæsthesia or paralysis, and yet there is a very marked indifference to the attempts of the currents. Some do not feel even the stronger currents; and others do not receive, or rather give no evidence of receiving, any impression from their in-working. For such reasons, great precaution is necessary in the employment of electric currents, particularly in giving the first *seance* for a new patient, until we study the temperament; even then we cannot

always be quite sure that the patient will bear, or need, in the evening, what he took in the morning.

Accidents from the indiscriminate use of electric currents, or from carelessness in their use, or where absolutely injudiciously applied, as to the case, the length of time, the strength of the current, or the direction of the current, are real and serious. When it is not managed so as to produce good effects, it *may* be doing an evil work. Indeed, the very same current that is not only harmless, but beneficial, for one, to another of the same age and sex may prove so powerful as to be actually injurious, or so inadequate as to be quite inefficient. There may be produced, then, from too strong a dose of it, or too prolonged use of it at a time, a bruising, or soreness, or fatigue, or exalted irritability, a neuralgia, or even cerebral congestion and hemorrhage. Now, some of the *slighter* of these effects are possible to be produced at the most prudent first *seances;* but in such a case the difficulty can be easily eradicated by treating it at the next time as an original and independent derangement.

The author fully believes that where electric currents are applied to the patient *without regard to the laws of their action on living tissues*, they may by chance produce, instead of amelioration or cure, an actual aggravation of the acute or chronic malady, which degree may remain (as he believes he has seen unmistakable examples) equally as persistent, as a correct use of the same currents will cause a bettering, (by producing the opposite polarization of the nerves, fibrils, and muscle fibres,) or even a complete restoration, that is also persistent. These are no imaginary evils. Scarcely a week passes but that some poor invalid sufferer presents for examination or treatment, who dates the "*growing worse*" from a given time, when "galvanized" by some travelling "*electropathist;*" or perhaps an officious neighbor brought a battery and applied the currents so shockingly, perseveringly, or repeatedly, that the hands were cramped, the muscles pained, and the limbs tetanized. *From that time* the paralysis was greater, or the pain along the course of the nerve trunks more acute, the aches in the joints more profound and unbearable, or the contraction of the limb more per-

sistent. The would-be doctor may give bread pills for *placebo*, or dabble with ipecac, rhubarb, and saffron, but *never* with the contents of the surgeon's case, nor yet with the currents of electricity.

Before commencing the treatment of a new case, it is well first to ascertain as near as possible the extent of the pain or palsy, deficiency or deformity of the muscle or limb. I usually make a record, for example, of the angle of the tonic contraction — of the coldness or heat of the limb — of the height to which the patient can raise the hand or arm laterally, or in front, as well as behind the back — measure the *atrophied limb* very carefully, and ascertain the precise character of pain or remaining sensibility and muscular response to various stimuli. In the lower limbs, in case of sciatica, rheumatism, palsy, or spasmo-paralysis, it is important to find the angle the thigh can make on the body — how far apart the patient can separate his feet, or his knees, by his utmost effort, &c. Thus to scrutinize severely, *in the commencement* of each case, the minutest peculiarities, and the degree of these, for the correct application of Galvanic or Faradaic currents, although unable to accomplish an improvement in some cases, yet in others not unfrequently the very first five minutes may obtain a partial and *permanent* bettering that would not otherwise be accredited.

Especially must we always bear in mind the great difference there is in persons as to susceptibility to the influence of the *different* currents; and for that reason alone we should begin very gently, and make the first *seance* as short as the obtaining of some given end is had. Some persons, we find, can bear the most powerful and frequent applications of any form of currents without experiencing any after-workings; — while there are many others, who, after a single active trial, experience chills down the thighs, or drowsiness, or even lassitude. But others more frequently find from it a most refreshing sleep, where they had not had such before perhaps for months or years. Even an inability to sleep may appear in others after the first few sittings; but this usually gives way finally to most comfortable rest. By watching such after-workings we shall be able the better to

regulate the frequency and activity of the *seance*. All these sensible by-workings and after-workings of the current appear only at and after the first applications, if the physician rightly graduates the strength of the current to the endurance of the case.

It is but a prejudice, and without any foundation whatever, to suppose that old people, little children, and extremely feeble persons, should not receive this kind of medication. Indeed, in my own judgment, these are the very persons to share in these blessings, only it must be adjusted to their endurance, kind of health, or derangement. Dr. Remak says it is his experience that the galvanic current is of the greatest value to aged and infirm persons, particularly for *prematurely old* men and women. He also found it of very peculiar advantage to "*atrophic*" children. Probably this reference is simply to puny children, or to the marasmus, rickets, and scrofulous diseases of children.

The smart, prickling, or painful sensation of the current can, as a general thing, be a standard to guide us, or at least aid us to judge, as to how much the patient can or should bear. Yet we must bear in mind that there are cases, also, (as paralysis proceeding from the spinal marrow,) where the sensitive nerves are so utterly unexcitable that, although the entrance and leaving of the current causes the strongest contractions, the currents are not *felt* in the least. In such a case we must not proceed *trusting to this standard*, but refer to the number of elements, and to the galvanometer; or, if using induction currents, we must regulate the soft iron within the helix.

Methods for using Static Electricity.

Friction electricity has long been, and *still is*, *valued for arousing and increasing the vital powers where simply sluggish*. The author has found it of very marked advantage for some invalids *who*, after great sickness or calamity, *remain in a low state of health*, and yet present no discoverable reason why they should not get better, only that there is a low tone of the nerves and functions, that cannot be reached by medicines or regimen. For

these patients, young or old, the positive *electric air-bath*, taken sitting or reclining in an insulated easy-chair, with the feet upon the insulating stool, for half an hour a day, and occasionally alternated by sparks *drawn*, is a rational and often successful remedy. The machine requires to be turned very *steadily* and *quickly*, while the chain or rod director from the prime conductor is held in the patient's hands. At the same time, see that ample provision is made for the escape of the negative electricity — i. e., from the rubber end of the electrical machine to moist ground, or to some mass of *iron*, if near by. This can be done by a chain leading from it to the water or gas pipe. A dry brick wall, we must remember, will not always do this well. Now, as the patient becomes more highly charged positively, the hair will rise; and should the room happen to be dark, numerous sparks and luminous appearances will be observed, because the atmosphere about the patient is rendered negative, as it always is about a highly positive body. I have repeatedly heard the patients say, in the course of five or ten minutes after the *seance* begins, that they are warmer, and feel exhilarated. The circulation is found to be decidedly accelerated; and the secretions, especially the perspiration, become more active and general.

To give the *negative electric air-bath*, we have only to change the conductors so that now the prime conductor connects with the earth, while that of the rubber must lead to the patient. This negative electric state *is said* to be an electric antiphlogistic, acting by depriving or drawing off from the organism its morbid accumulation. But we cannot see the reason, nor can we corroborate these deductions from any experience, as in our hands the testimony on this point has always resulted negatively. (See p. 98.)

Sparks may be *given to*, or *drawn from*, any part of the body, but they can be most readily obtained on a dry surface; for if the skin or the patient's clothing is moist, the discharge is thus dissipated, and we get no spark. *Electrization* by this means has been greatly esteemed by some experienced physicians for its success in curing chorea, hysteria, colds, rheumatisms, some forms of paralysis, and neuralgia.

While the patient is sitting in the *insulating chair*, and charged *positively*, sparks can be *drawn from* the body by applying any conductor near to the patient. If the person is being charged *negatively*, the same manœuvre will *give* sparks to the spot where it approximates. In either case there is a vivid flash of light, which, so far as it goes, is a streak of lightning. This is always attended with the sound of a sharp crack, as the negative electricity instantly combines with the positive. The sensation of a spark on the skin is like that of a slight prick of a pin; and this pricking sensation is in proportion to the *length* of the spark, as well as according to the *sensibility* of the part. Hence it is necessary to proceed gently with this by holding the ball of the conductor *against* the skin, or *very close to it*, at the commencement, until the patient gets a little accustomed to its sensation, when the discharger may be carried farther off to give longer and stronger sparks, and produce a greater effect. Giving sparks does not have so much effect locally as *drawing* the less frequent but longer sparks; for this latter produces a local accumulation of high-tension electricity in the skin and sub-adjacent tissues near the spot where the ball approaches the body. Here is the simple and most true localization of electricity. This method of applying electricity for the sick has been much employed for many years as the most efficient and reliable remedy for given cases, by Dr. Golding Bird, in the "Electrical Room" of Guy's Hospital. The *method* there adopted was as follows: A brass ball-tipped director, (discharger,) with an insulating handle, was furnished with an adjustable chain, or large wire conductor, which is put in thorough connection with the ground. This, I find, is more readily done by using a good-sized chain, — say half inch, and silvered, — with a smooth hook on its end, to be readily adjusted on the metal shank of the discharger, and passing the ball of the discharger gradually and wavingly, more or less close, up and down the spine, within about an inch or so of the surface of the body or limb. It is understood that the patient is being retained positively charged by the unceasing action of the machine from friction, that keeps up the supply to the body, which here escapes to the ball and chain, and so to the

earth. By holding the ball very near the skin, the sparks are so rapid as to form a mere interrupted one-way *current*.

Shocks from the Leyden jar are much employed in Europe for *amenorrhœa* by directing the discharge through the pelvis of the patient, from the sacrum to the pubis. When it is desirable to discharge the shock through any given part of the body or limbs, and that in a certain direction, we use a double discharger — i. e., one with a glass handle, and with two arms, that may be jointed and adjustable, or not, but the arms are tipped with bright brass knobs. One of these knobs we bring in contact with the point or region where we wish the charge to *enter* the body or limb. Then, if the outer coating of the charged jar has been already made to communicate by a good and ample conductor which is adjusted so as to lead to the point of the body or limb where we wish the charge to *leave* the body or limb, and we cause the second knob of the discharger now to approach the ball on the top of the Leyden jar which communicates with the inner coating of the jar, the jar is instantly discharged through the part of the patient so positioned. If the clothing and person of the patient are moist or wet from perspiration, it will require care and no little adroitness to succeed.

Dr. Cavello early published a small essay on "The Uses of Electricity in the Practice of Medicine." He strongly urged then the use of the machine in cases of paralysis, poor sight from want of nerve power, nervous deafness, chorea, epilepsy, and for restoring those who had fallen into the water, as he had succeeded best in all these with friction electricity. Dr. Cavello's method was, to *draw the sparks through dry felt* or flannel. The patient sits insulated as usual, and takes the chain to the prime conductor of the machine in his hands; a piece of perfectly dry flannel is placed over the part which is to be electrified; and, the machine then being put in action, the brass ball or knob of the director that is in connection with the earth is then brought in close contact upon the flannel, while it is regularly and slowly moved along the part affected, and thus made to draw a succession of minute sparks through the cloth, as, for example, along each side of the spine, over the roots of the compound nerve

trunks, as they take their exit from the cord. We may sum up the uniform local effects upon the skin and underlying tissues, as being in direct proportion to the efficiency of the machine, the length of the spark, the repetition of these sparks, as well as the delicacy and sensitiveness of the skin of the part operated upon.

The *electric shock*, it is well known, is given from the Leyden jar; one or more being employed, according to the power required. It is also known that in this arranged jar there can be *accumulated* a considerable quantity of electricity of the highest tension, and that on a comparatively small surface. The jar can be charged either positively or negatively. To charge it positively, the brass knob at the top of the jar is made to communicate with the prime conductor of the electric machine, while the outer coating communicates with the earth; then some thirty to fifty turns will charge a one-quart Leyden jar.

Methods for employing the various Electric Currents.

In the more recent German and Italian medical writings we find evidence that some leading men there are giving more special attention to this particular department of "*therapeutics*," than we find either in France, England, or America. Dr. Duchenne, however, was the first to partially recognize the great fact, *that there are certain spots along the surface of the body and limbs that give very peculiar response to the electrode in producing more ample muscle contractions without pain.* Simultaneously, and still more clearly, was this remarkable circumstance *discovered* by Dr. Robert Remak, of Prussia. He says, "After numerous trials on the different parts of living men, I am prepared to say that I believe I can explain those spots, or 'border points,' alluded to by Dr. Duchenne, as observed by him, but in only two muscles." In a very recent foreign work by Dr. Maurice Meyer, on "The Uses of Electricity in the Practice of Medicine," published in Germany, there appears the following description of his method: —

"*To produce electric excitement of the 'motory nerves,' or*

of the muscles, we must lay wet excitors with active induction currents on those points of the skin which lie as much as possible immediately over the said muscles. We find that the surface muscles of the trunk, as well as those of the extremities, by operating in the manner thus prescribed, may easily be made to *contract;* while many of the deeper lying muscles may be reached in the region of their *source*, or of their concourse,—*for there are such places*,—where they are peculiarly accessible to the direct in-working of the electric current. Where this is not the case, we must apply a more intense current, or have recourse to *Indirect Faradaization*, which, though probably less efficacious, either as effect or as remedy, is, however, here to be preferred." No mention whatever is made of placing the electrodes with reference to the oblique course of the fibres of the muscles, nor yet is there any allusion to the action obtained as being through the nerves, but direct excitement is plainly inferred. The fact of muscle *border points* has here too, doubtless, been observed; but its bearing for practice was not discovered.

I have elsewhere said—and it should be particularly borne in mind—that all persons are not in a like degree susceptible to the influence of the various electric currents. Not only does the application of the Faradaic currents show a surprising difference between one person and another, but I find that this can, and does, vary in the same individual from day to day; yes, even from morning to evening. This result of actual experience should have a place and bearing in the mind of every physician, as regards the widely varying susceptibility of different patients, and even of the same patient at different times, to the influence of a given dose of the various medicines, as well as to Faradaism or Galvanism.

There are cases, we know, where even the indiscriminate applications of small, wet electrodes to the surface of muscles, and with very moderate induction currents, such as are quite supportable by the sentient nerves, will sometimes produce a contraction of the whole muscle, or at least of the surface fibres of that muscle. This result is obtained most readily in proportion as the skin at that point is thin, and the muscle is also thin and

lean, yet rich in nerve fibrils; as, for instance, on the muscle *trapezius*, or the *pectoralis major*. Here we can generally cause one or more bundles or layers to play at will, and this is the species of phenomena to which Dr. Duchenne refers, to prove the direct in-working of the Faradaic current through the muscle fibres, *independent* of the nerves; for he advocates the doctrine of Hallerian irritability.

If we test the muscle *biceps brachii* with *moderate*, i. e., painless Faradaic currents, we obtain scarcely any visible effects by placing both the electrodes on the ends of the muscle fibres; in no case, however, do we thus effect a perfect persistent contraction, or even a bending of the forearm. But if, now, without increasing the strength of the same current, we remove the electrodes, and place one on the middle of this muscle, while with the other we seek the point where the *musculo-cutaneus* nerve goes behind the muscle, — this taking place, as is well known, in the region of the upper quarter of the inner border of this muscle, — it may happen that instead of obtaining the expected *contraction* of this muscle, and consequent bending of the forearm, we produce effects on the muscle *pronator teres*, or even on the flexors of the fingers. When this is the case, we know that the electrode was too far back, and the current has therefore touched the nerve *medianus;* or we may even obtain an action on the muscle *triceps* when the current has reached the nerve *radialis*. In either case we must move the electrode a little forward and upward, when we shall find that point out of which a fair contraction that flexes the forearm can be produced, *and that without the least pain*, if no large branches of skin nerves are embraced by the electrodes.

Again, if we make a similar trial on the muscle *trapezius* by placing one electrode just beneath the *occiput*, so as to rest upon the upper end of this muscle, while the other electrode is planted over its insertion in the *spina scapula*, and consequently in the direction of the muscle fibres, we obtain no effects of importance, except an aching pain in the shoulder blade, or in the occipital region, i. e., if an occipital nerve has been touched by the current. But if we now leave either one of the electrodes

where it is, and seek with the other over the anterior border of the muscle, in front of the shoulder, for that point where the nerve *spinal accessory* of Willis passes under the edge of the *trapezius*, we at once obtain a very powerful and painful bending of the head backwards, or laterally, or else a lifting of the shoulder, according as we have left the first electrode near the back of the head, or near the shoulder.

If we make the trial on the *sterno-cleido-mastoideus*, by placing the electrodes on the respective ends of that muscle, and using, as in the former trials, the Faradaic currents of moderate strength, we obtain no nodding of the head; but if we increase the current we get a contraction, and perhaps this is accompanied with some pain in the region of the ramification of the main *auricular* branch of the *cervical plexus*. But if we place one of the electrodes on about the middle of the muscle, and then seek with the other along the outer border of the muscle, that *point* where the nerve *accessorius* of the eighth pair passes under the back edge of that muscle, we immediately obtain strong and painful nodding of the head, accompanied perhaps with a *by-working* on the muscles of the tongue and throat that depend upon the nerve *hypoglossi*, if we touch or include that nerve ganglion. This, however, can and should be avoided.

There are persons with peculiarly torpid facial muscles, on whom the placing of these electrodes with this current in the course of the muscle fibres, produces almost or quite no effect whatever; but contractions are quickly produced by placing one of the electrodes on the middle of the given muscle, while the other hunts the exact spot where the branch of the nerve *facialis* (*portio dura*) enters it. This is readily tried on any one, and safely too, by testing the muscle *depressor anguli oris*, or the muscle *frontalis*, or the *attollens auriculæ*.

In many muscles we often find, as, for instance, in the *orbicularis palpebrarum*, the placing of both electrodes to the same muscle is not always altogether advisable, on account of the in-working of the then necessarily strong current on the eyeball. The isolated, painless, and harmless together-drawing and pursing of this muscle is better obtained by placing one electrode

over the *entrance spot* where the nerve enters this muscle, which is at its outer border, while the other electrode may be somewhere near, so as to embrace the muscle fibres, and that with a very gentle current, for the great excitability of these eye muscle nerves, renders it quite sufficient for one electrode, or the route between the two electrodes, to merely graze some of the nerve twigs, or muscle fibres to produce its complete physiological action.

If we return to the muscle *pectoralis major*, and place one electrode on almost any part of the muscle, while with the other we seek the spot at its upper border and just under the *clavicle*, where the nerve *pectoralis anterior* comes from under that bone, we shall produce prompt and powerful together-drawings of the *whole* muscle. And this can be done if the first electrode is placed *on* the muscle, or even *beyond* it. Quite analogous results can be obtained on the muscle *serratus anticus*, or on the fleshy muscles of the forearm, or of the leg. Here we cannot but notice some difference between the excitability of the muscles that partake in the acts of respiration over those of the extremities, as the former are so much the easier to affect; but in every case we shall observe the bearing and importance of the increased effects produced by the same means, used by different methods; i. e., by not so strictly and invariaby following the "*localized method*," according to Dr. Duchenne, but calling to our aid *also*, on every proper occasion, the appeal to the muscles *rather through the nerve branches or nerve trunk.* This, in my judgment, after no small clinical practice, has, I must say, a decided preference, both for immediate visible or sensible effects, but *much more for the profound and lasting impression which in effect, we know is the cure.* Herewith I wish to urge the importance, then, of not being always satisfied with simply bringing a portion of the superficial muscle fibres, or the smaller terminal nerve fibrils, under the influence of the electric current; but we are to endeavor to reach *also* the nerve branching, and even the large nerve trunk of the part, that this subtle current may traverse them for a given time in a certain guided direction; but more particularly must we seek *that point*

where the motory nerves have their entrance place into the muscle. It is from such a point,—besides these general and specific *rules*, a point or points on the surface of the body and limbs, whose latitude and longitude must be familiarized by experience in practice, and, still better, by systematic pre-trials on the *recent* subject, and on healthy persons, — that we can govern the action of the muscles most surely, most completely; and besides that, and which is of far more importance, to my mind, disturb and break up the abnormal polarity of the nerves most profoundly; thus leaving them in a condition so that their natural equilibrium of function can be by nature's tendencies again established for permanency.

If we desire to embrace in the current all, or as nearly all the larger branches of the nerve as possible, we must place one electrode over the highest reachable place for the entrance nerve, and the other over the forks of the first large radiating branches, as they enter and spread in the muscle, which will *usually* require the placing of the second electrode not far from the first.

What was said in regard to the electrizing of the muscle *orbicularis palpebrarum* will apply in some degree to nearly all muscles whose motory nerves, at the time, possess the requisite amount of excitability; for if we place one electrode on one of the *border points*, — and by this I always mean the entrance place of the largest nerve of that muscle, — the other electrode may even be a little beyond that muscle, and yet produce some considerable effect; but this latter has no value in practice. It may perchance become serviceable where we intend to place two muscles in motion simultaneously from their common border point by means of one and the same current. The practised medical electrician can readily trace the form and extent of each of the muscles on the face, and also the course and extent of the branches of the *portio dura* even within the muscle; and besides, there often can be defined the course of the branches of the tri-facial, which are sensitive twigs, by the response in a sharp, lively pain, to the track of the electrodes, wherever they lengthwise or obliquely cross, cover, or embrace the fibrils of any of these nerves.

Although Dr. Duchenne appears to have been the first to notice the *border points*, or what he called "spots," on some one or two muscles, which were the *sterno-cleido-mastoideus* and the *trapezius*, yet he evidently did not comprehend the *law*, nor even the cause and bearing of the phenomenon. This observation, too, corresponds very much with the "*painful points*" discovered in neuralgic cases by his countryman, Dr. Valleix, some dozen years before, indeed exactly so in many instances; yet it appears to have remained without influencing Dr. Duchenne's general or special "methodical localization."

Not only from his work do we judge, but those who have seen him operate say he places the two electrodes (which are large) upon the surface of the muscles without any apparent rule or order, and thus usually succeeds in producing visible contractions, it is true, but only because he makes use of tremendously strong inducing battery currents. We are to understand that he always operates with the Faradaic currents; but to drive his large helix machine he employs *eight jars of Daniell's original batteries!* No such *induction* battery arrangement is ever used in this country, that I know of, for medical purposes.

It appears that Dr. Remak, the distinguished medical electrician of Berlin, and Dr. Duchenne, the great French medical electrician, recently met in Paris and made trials of their different methods of operating on the same subjects, for the same diseases, and with the same induction apparatus; which was the *Duchenne Machine* just alluded to. The patient had been suffering with lead-palsy. Dr. Duchenne made the first applications, and as soon as the flexors of the fingers were thus put in motion, the patient expressed insupportable pain, as he said, and as his countenance and actions also indicated. He was then requested to bring the muscle *biceps* into contraction, which he did by placing the electrodes — which, by the way, were large, wet sponges, stuffed into the hollow ends of common metallic handles — on the surface of that muscle and in the direction of its muscle fibres, when he obtained a visible contraction and plumping up of the muscle; but there was *no* bending of the forearm by it, while the features of the patient, in the mean

time, betrayed great pain, and an unwillingness to have it prolonged. The intensity of the current of this powerful helix machine was then weakened down as much as possible, aided by means of a glass tube containing a column of water, which was interposed in the circuit. Remak then took the same electrodes to electrize the same muscle of the same patient. He produced, it appears, at the first application of the current to the nerve trunk and *border point*, an accessory action on the nerve *medianus;* but after moving the upper electrode a little, *a perfect and painless contraction of the forearm was the result*, while the tetanic-like contraction indicated the true source of the phenomenon. The patient gave a thankful and astonished look at Dr. Remak, and answered his questions by saying, with a shy side glance at Dr. Duchenne, that he had not experienced the least painful sensation. Next, according to his own method, Dr. Remak tested the muscle *pectoralis* and the *rhomboideus* through their nerves, which he caused to contract most powerfully, yet without the least pain. It appears that Remak did not deem it expedient to show this trial on any other muscles and nerves than these two, which Dr. Duchenne had already observed in like manner before.

Methods for using the Primary Currents of Galvanism and the Secondary Currents of Faradaism.

A few remarks advanced by Dr. Duchenne some years since, in his great work on "Localized Electricity," respecting the inutility, and even "*danger*," of employing the primary galvanic current for medical purposes, have proved an effectual guard against its remedial use of late; so that almost no experience with the primary current has been obtained for the last ten years, excepting by a very few, whose testimony, however, is too high to be either overlooked or disposed of summarily. The first I will mention is that of Dr. Robert Remak, of Berlin, whose indefatigable labors and learned deductions command, at least, a respectful hearing. To understand this Prussian philosopher, we must observe that he is not a believer in the "*vis*

musculosa insita." He is evidently a very learned physician, and ranks as one of the most eminent physiologists in Germany, having had years of experience in the use of the secondary currents of electro-magnetism, and magneto-electricity in medical practice; but, by an unexpected process and succession of results therefrom, it appears that he became a warm advocate for the employment of the so-called "constant" (or primary) "*galvanic electric current, for therapeutical purposes.*" Being the contemporary of the no less distinguished Dr. Duchenne, of France, who employs almost exclusively the interrupted, alternated, "secondary currents" of *induction* for medical purposes, they therefore became opponents in this world-wide discussion.

According to Dr. Duchenne, "a *weak* and continuous current of galvanism, when '*localized*' on the skin, will produce pains, erythema, and even blisters; while a stronger current will produce, when carried into the substance of a muscle, only feeble and irregular or uncertain contractions." This, at least, says Dr. Duchenne, "is the result of *an experiment* which I made on myself with a battery of one hundred and twenty Bunsen's elements. This constant current also produces the evidences of heat in the profundities of the organism, all of which phenomena are wanting if we use only fifteen to twenty elements." (!) In the fourth chapter he gives further proof by citing a case showing the workings of the steady current on the *retina*. It there appears that some kind of a new electrical apparatus was brought into his office by the inventor, while a patient was in the operating chair, suffering from a paralysis of the face. He thereupon made trial of this new machine, when, lo! the patient at once almost lost his sight. In the second case there also was brought in to him a new galvanic arrangement, (his own invention,) known as the "*Pile à rubans*," just as he was treating a patient for double-sightedness. When the doctor applied the current of this to the eyes of the patient, the latter jumped up, shook his head, and then exclaimed, "You have only *one* head! I no longer see double." This, in fact, is about all that we find from Dr. Duchenne on the physiological or therapeutical value of galvanism by a so-called constant primary current. True, he also

mentions the fact that the constant current is less painful than the interrupted induction current, and as producing quick erythema, and even blisters. Speaking of the constant current apparatus which he employs for treating diseases of the retina, — *pile à rubans*, made of copper and zinc *ribbons*, moistened with the vinegar of wine, and hence extremely irregular in tension, — he says it (galvanism) is so uncertain in action, and so unmanageable, that it is quite unsuitable for other physiological or therapeutical purposes. Such are the amount and result of his experience, according to his own showing.

M. Becquerel, the discoverer of the more true physiological action of the primary currents of galvanism; M. Dubois-Reymond, the discoverer of the most fundamental *laws* in electrophysiology; and M. Remak, who first put these into practice clinically, and thus gave a tangible starting point for "galvano-therapeutics," — are names the medical world will yet more and more recognize and cherish. The latter, in speaking of his first bedside experience, says, "The results of my first applications of the galvanic current were quite contrary to what I and other medical men had been led to suppose." He observed that the constant current, when in reasonable strength, and managed with common sense, instead of "*necessarily*" weakening a nerve, or the excitability of a nerve, *could*, on the contrary, be so guided as to *increase* its excitability, to a certain degree, as is plainly shown in the sensitive nerves by an increased susceptibility even to a weaker current; while, in the motory nerves, it is manifested by the *increased strength of the contractions* that are produced by the occasional interruptions of such an exciting current after a long in-working. He also early observed that the natural voluntary capability of a muscle, or set of muscles, to contract and act normally, is increased more rapidly after being first a little excited by moderate induction currents, as done in the usual manner for such treatment, and then using the steady primary current, directed, for a certain length of time, both through the nerve trunk and the afflicted muscles. To illustrate his particular views, he gives the following case: —

A man who had suffered for seventeen years from violent pains

in the arms, hands, and feet, accompanied with swellings of the joints, especially of the fingers; in fact, it was a case of old gouty rheumatism, with contractions and nodosities, of long standing, which had resulted in great helplessness, atrophy of muscles, and trembling in the limbs. When the patient was undressed, there was a visible wasting from the shoulders to the hands, and that with oscillating motions in the flexor muscles, which were soft and flaccid, with the exception of the *biceps*, which was, on the contrary, so hard and contracted that the extension of the arm, or the lifting of it above a horizontal position, was quite impossible. A *seance* was decided upon. "Some thirty-five elements of Daniell's batteries were switched on the key-board, and, by means of small brass-ball electrodes covered with wet wash-leather, this current was applied through the shoulder and arm, in all for about six minutes, as follows: First, *from* the nerve *thoracici to* the nerve *circumflexus humeri* for one minute; then *from* the same point to the anterior portion of the muscle *deltoides* for one minute; then from the *deltoideus posterior* to the nerve *circumflexus* and *fossa supra-spinata* for one minute more." It will be observed, he says, that the current had so far been running mainly in an upward direction, with only some changes of position for the electrodes, and with momentary recesses. Now, the patient was required to try the motions of the arm, and it was at once evident that he could move it about easier; and not only so, but he could raise it better, and with less pain and trembling. Again the electrodes were applied, the one in the *supra clavicula fossa*, while the other was on the lower portion of the muscle *biceps*, and now with a down-running current: thus it was let on for one minute. Then, after a recess of a few seconds, it was again let on in the same manner for one minute more. Next, the one electrode was removed to the upper and posterior portion of the *deltoides*, while the other electrode was planted on the lower third of the muscle *triceps*, and this, with an up-running current, was retained for one minute more. Thus ended the first *seance*.

But I should have mentioned that by this the patient was a little "suppled," and but a little. I also wish to remark, as he

has neglected to do it, that when the electrodes are thus situated over a nerve trunk or bundle of muscle fibres, it is best to disturb them a little, certainly as often as every ten or fifteen seconds, in order to produce *variations of density* in the constant current, as advised by Dubois-Reymond; and if the one that is over the muscle is slid along, *not all the time*, but say from three to six times during each minute, so as to cross and embrace the different bundles of muscle fibres, the benefit is found to be all the greater. On the next day he says that patient was brought again to receive further treatment. "The *seance* was repeated as before, but he could bear now only twenty-five elements at most; but there was directed, in addition to the above, for each side, a current of sixteen elements running *from* the nerve *thoracici* in the *fossa subclavicularis to* the muscle *pectoralis major*, or that portion of it that lies over the third and fourth ribs. The patient is now evidently better; pain and trembling less;—to come the next day. Thus for a fortnight he was treated, first, two or three days in the one limb, and then the same in the other limb, and that with a general improvement, except in the enlarged joints of the fingers and toes. The patient has been able to be about for the past six months, and, instead of relapsing, is still decidedly improving every way to a high degree of health, with the only exception of the enlarged joints."

Dr. Remak introduces the following case to show again the remedial effects of the primary current of galvanism, which is, perhaps, more familiarly known to some as the "constant current." The case was one of cramps, with a rigid persistent contraction of the middle finger of the left hand, which had from time to time gradually extended up the flexors of the arm to the shoulder, originating, according to the history of the patient, doubtless, from a central source. He therefore directed at first a current from fifteen Daniell's batteries, in his usual manner, through the shoulder muscles, when he observed at once that the up-running current produced in that arm a twitch at the opening of the circuit. This, he says, he always regards as a sign of *abnormal* hyper-excitability, not produced by the cur-

rent, but a manifestation of an already existing susceptibility. He continued this treatment a little, when the arm movements were found to be loosened in every direction. Similar manœuvres were then repeated, as also a current run down from the muscle *pectoralis*, first to its insertion in the *humerus*, and then moving by gliding the positive electrode farther and farther down the arm by gentle hitches,—done every few seconds,—following the course of the muscle nerves; whereupon most remarkable bettering effects were found to have been produced. In the course of every two or three days the *seance* was thus repeated, always directing the variations of the current, he says, much through the broad-spread fibres of the pectoral muscles, which, in a word, was followed with very decided and lasting good results. He states that he introduces this case merely to show by the results thus obtained, the confirmation in practice of the capability of this current of galvanism to increase, (even in palsy, rigid contractions, and atrophy, *whose central source could not be doubted*,) and entirely restore again the normal action of those blighted muscles and limbs.

When treating of the physiological action of the primary current, Dr. Remak says, "I found from the multitude of my electric treatments, and especially from my experience with such patients as had been previously treated by some other surgeons with the induction currents of magneto-electricity or electromagnetism "*powerfully localized*" on the muscles, according to Dr. Duchenne's method, and particularly *in those cases of paralysis that arose from a central cause*, that although there were readily produced a plenty of tetanic or clonic convulsive movements in the affected muscles, by means of the *induced* (secondary) current, still they did not appear to restore the *voluntary* motive power; but, on the contrary, they sometimes evidently lessened this where it already had existed in some little degree, and that this *capability for voluntary action* appeared to be thus actually diminished by the strong induction currents, exactly in proportion as the given case of paralysis was depending at the time on a central source." (?) Subsequently, he treated alternate patients, in great numbers, by these two different kinds of

electric currents; and the total results completely confirmed him in favor of the use of the primary current of galvanism, if used by a given rule, especially for those cases of paralysis, contractions, and fixed joints, *that depend upon an existing central lesion!* This, the greatest proposition of Dr. Remak, the author of this work cannot fully indorse; it savors too much of rash and unqualified statement, or of hazardous treatment; still, there is doubtless involved here a great physiological *principle*, that, we hold, should be watched and studied more and more, *as one of the very fundamental laws of both disease and cure;* viz., "reflex action."

In order to render the electro-muscular contractions produced at the *seance*, in the paralytic, of lasting and curative service, he says it is necessary to change the gross, uncertain, and partial muscle-fibre contractions into actual *twitchings*, or strong together-drawings of all the fibres of a sick muscle, either through the aid of a sentient nerve which is simultaneously touched by the current; or, if this cannot be done, try the manœuvring of the current after Volta's or Ritter's method, or such other polar alternations as will change the point of entrance of the current, so as to be first at this and then at that pole, whether the direction of the current is also changed or not. He believes that the closure of a moderate, primary current of electricity through the nerves, in any case of "paralysis from a central cause," produces a favorable result, only and *provided* that, at each closing and opening of the circuit, during the *seance*, we are careful to make that electrode that is over the more external or distant nerve ramification, to vary in pressure, or position every now and then, (i. e., every quarter or half minute,) so as to wave or vary the density of the current, both before and at each putting on and taking off the electrode from the skin.

M. Hildenhains has used the so-called constant primary current of galvanism for therapeutical purposes, and has reported some trials made under the auspices of M. Rayer. But here was used a very different apparatus, and this, too, in a very different method from Dr. Remak's practice. The former employed *Pulvermacher's chain*, which, we know, is composed of

numerous small bits of copper and zinc, that are moistened with wine vinegar and then placed upon the patient, who wears them for some six to twelve hours together. Thus he aimed to make up by time with a weak current, what the latter sought to do by more active currents in a shorter time. But there appears to be no comparison in the results. The apparatus that Dr. Remak uses (a compound Daniell's battery) gives a very constant quantity current, with little heat, that is entirely under his control to wave, interrupt, or reverse at his will, and that with a power capable of changing the polarity of the deepest nerves, of producing the contraction of the muscle fibres, and the dilatation of the vessels; while the Pulvermacher's chain, being poorly made, and worse applied, is an inconstant current, working when and where it may happen. This probably was the origin of the once celebrated "*Christie's Galvanic Rings and Belts*," that so flooded our country. Dr. Hildenhains advised the placing of one pole of this pile on the central organ, i. e., on the spine, while the other end of the chain, or pile, was planted on the diseased part. This was necessarily a failure. But, no doubt, if the current could have been uniform, and directed only for certain cases, this would have rendered essential service in many diseases.

M. Robert Remak made his pre-trials with constant or primary currents of galvanism, with reference to medical practice, first on his own person. It appears that he took some forty of Daniell's elements, and from such compound-battery he applied the current to his arm; but, finding this too painful, he then used only thirty elements. Thus, by trials repeated first on himself and then on others, he arrives at the following rules, (as he considers them,) which are condensed from his work: —

1. The conduction of a strong and somewhat painful current is required to be directed through a nerve trunk, in order to produce in a muscle or limb a *general* tonic together-drawing, or, in other words, a fair muscular contraction.

2. If a current, by coursing through a nerve, succeeds in producing a tonic contraction, then this contraction could have been produced whether the current embraced a greater or

less extent of the trunk of that nerve. For instance: if we test the nerve *medianus*, it is sufficient to embrace between the electrodes only that portion of this nerve that lies along the border of the lower third of the muscle *biceps;* but the facility of the nerve excitement and the resulting contraction, *increases with the length of the nerve extent that is included between the poles.*

3. A tonic contraction can be produced by directing a weaker, steady, and continuous current of electricity through a nerve trunk, even in cases where, if the same stream is applied in a similar manner but directly *over* the muscles of that same limb, it is not able to produce even an opening convulsion.

4. A current can cause insufferable pain without a tonic contraction being produced; while in another person, or even in the same person at another time, that same current produces strong tonic contractions, and scarcely any pain.

5. The production of the tonic contraction is, however, generally facilitated by the same conditions which also make the "closing convulsions" lighter; and that is, by a sudden letting on of the current. But there are also cases where only after a moderate and partial removal of the electrode from over the nerve trunk, where it has been applied for the minute before, the tonic contraction commences in the reach of that nerve, and lasts as long as the electrode is thus lightly touching the skin with a moist contact.

6. From twenty to thirty of Daniell's elements are usually sufficient to produce a visible tonic contraction on the arm of a well man. But there are persons who require even double that number to show this phenomenon. When a tonic contraction is not produced at the first application of the electrodes, it usually appears on the second application; i. e., after the first application has been retained, and thus allowed one minute, or so, of in-working to quicken the nerve sensibility. This occurs in those cases where the current obtains only the lighter "entrance convulsions" when applied directly to the muscles.

7. Most young people, and all who have strong muscles,

show merely tonic contractions in the reach of the nerve trunk that is traversed by the current. But the phenomenon can change in the same person on different days; i. e., the contraction can appear either in the reach of the so traversed nerves, or the contraction may show itself in the antagonistic nerve and muscles on the other side of the limb.

8. The *will* retains so much influence during the trial, that it *can*, when exercised, prevent the production of the antagonistic contraction. In such a case, however, the entrance of the current is generally followed by tonic contractions in those muscles and nerves, towards which the motive purpose is then directed; while, at the same time, the antagonists also experience tension.

9. Moreover, this combat between the flexors and extensors of a limb appears often *without any participation of the will*. In that case, it is seen that one of the contractions, which is usually the flexors, will soon dissolve or wilt down again, and that while the current is still running, so that the *prevailing* contraction goes over into the extensors, or *vice versa*.

10. Where a tonic contraction is produced and maintained by a current coursing through a nerve, we do not succeed, by means of the will, to give superiority to the antagonistic contraction.

11. It is by no means probable, that the antagonistic contraction is merely the consequence of a psychological act; for we notice the phenomenon equally in those persons who are wholly unacquainted with the subject, or object, of the test. Yet it is equally true, that it is difficult for many persons to entirely avoid exercising the will, particularly at the moment when the current enters the nerve.

12. In those cases where the antagonistic contractions occur during the time the current is traversing the nerve *medianus*, the thought naturally arises that this is the effect of a current transplanted through the thickness of the arm, so as to act stronger on the accidentally more excitable *extensors* than it does on the *flexors*. If this explanation were just and sufficient,

says Remak, then a direct excitement of the antagonistic nerve trunk ought to produce contractions only in the reach of its own ramifications; and the same should happen also when the excitement includes both nerve trunks simultaneously. But in apparent contradiction is the following: —

Where a current, when traversing the nerve *medianus*, produces extension, i. e., a contraction of the *extensor* muscles, so as to open the hand, yet we find, as soon as the nerve *radialis* alone of that arm is placed in the current, or where the *medianus* and the *radialis* are connected, as by a wet bandage, so as to be under the same electrode which is placed on the upper arm, there is then contraction of the *flexors*. The same working and effect are produced when the end of the wet strip is carried from any point on the nerve *medianus* that is included in the circuit, to any point or part of the extensor side of the arm or forearm, *below* where the nerve *radialis* runs out to its ultimate ramifications. This same effect is sometimes produced when a wet strip is carried from the nerve *medianus* to the back of the hand or fingers. This *simultaneous* excitement of the nerves running out on the back surface of the arm and hand, when continued a minute or so, produces not merely a temporary, but also *a lasting*, *influence* on the tonic contractions. For if now the wet pad is removed, and the arm is perfectly dried, and the current is so directed as to course through the nerve *medianus* alone, we find we do not now get extension, as before, but tonic flexion; and it continues to act thus until, by repeated special voluntary motions, its extensors have regained their capability to respond to the excitement in the usual manner. It is quite necessary sometimes, after this trial, to rub the fingers and muscles briskly, to bring them back to their normal sensibility and capability.

13. However difficult it might be to find a common law for these paradoxical phenomena, it was highly probable that they could arise from some disturbance in the equilibrium of the central organs, as tonic innervation; or, perhaps, the excitement of the sentient nerves play a real part in the result. This latter suspicion was all the more confirmed by this, viz.: that,

after the current was made to traverse the nerve *radialis superficialis*, — which is a sentient nerve branch, — near to the radial artery, there is then occasionally produced an extension of the hand; and yet this effect is not apparent when the electrode is not on, or is removed rather to the one side of that nerve, even if but a trifle.

Such results obtained as pre-trials on man were then followed by the following trials and deductions: first, a current running in a downward direction through the nerve *radialis superficialis*, produced the extension of the hand; when the current was turned so as to run upward through the same nerve, there was closure of the hand. In another person, in health, it was observed that when the current traversed the nerve *medianus* downward, there was pain, with tonic extension of the hand; but when turned to run upward in the same nerve, there was less pain, but now tonic flexion. Thus it seems, says Remak, that no other explanation remained than this: *that these tonic contractions were really called in play by a central excitement*, which itself was caused by the action of the current on the *sentient* nerves; and that all those variations and differences observed in isolated cases arose from central variations mostly, but also in some degree from the variations in the susceptibility of the sentient nerves along the extent of their ramification — "*in a word, this is none other but a true reflex-action.*"

In 1858, he made other trials, and having already had much experience in the medical uses of electricity, both by *primary*, constant currents, (i. e., seldom broken,) and by interrupted *induction* currents, he seems to be confirmed in the opinion of the *main, central source* of these contractions. He cites the case of a woman who had long suffered from hemiplegia, in whom he succeeded in producing tonic contractions of the paralyzed extensor muscles of the arm, by means of the so-called constant galvanic current coursing through the nerve *cruralis* and its branches, on the praralyzed side.

The following trial, I think, is a very instructive one. If we take even a sensitive frog thigh, prepared after Galvani's method, and lead the current on to the nerve or muscles, not by means

of fixed electrodes, but merely by *wet threads* hanging from the electrodes, or wire poles, we find that the *closing contraction*, and also all tetanus, are avoided. Mark that, for it is both instructive and suggestive. Even when a stronger current is employed does this hold good — an end that M. Matteucci appears to have greatly sought for, as thought by him so desirable for given purposes. But the same thing is observed when the solid electrode is *not pressed* hard against the limb, but is rather held but very lightly to it. Hence we may infer, that a certain pressure of the electrodes over the nerves and muscles is requisite to produce the appreciable varyings in the density of the artificial current, which again produces variations in the native animal electric current, and this brings about the increasing degree of muscle contraction.

These like trials make it highly probable, therefore, that the galvano-tonic contractions, caused by a constant primary or secondary current, when directed through a nerve trunk, and observed in its depending muscles, belong mostly to those phenomena which are produced by variations in the density of the employed current. This explanation, moreover, throws light upon the fact, that a steady and somewhat protracted application of such a current as will cause a closing twitching in the nearest muscle fibres, — that is, in those portions that lie near to the larger nerve twigs, — forms a favorable preliminary to the production of such a contraction. Now, if the excitability of these fibres or their nerves is not considerable, the fibres remain motionless, i. e., after producing the closing twitch. But, if the excitability of these fibres or their nerves *is* considerably increased, then they will show, while under the action of the current, a fine and delicate trembling motion, and through this wavy motion of the muscle fibres, prevent the nerves from being affected in an equal measure. The nerve trunk will in that case be conditioned the same as if it were alternately brought near to and removed from the most dense current, without, however, being entirely out of the sphere of its influence; that is, the different parts of the nerve and muscle fibres will respond to currents of different density, on account of their possessing varying degrees of resist-

ance; and again, that in proportion as the muscles are depending on that nerve, they take on a contraction which may be either *tonic*, i. e., without interruption, or whose actually existing variations escape observation from being covered up with the skin.

Furthermore, "it is demonstrated in the living human being," says Dr. Remak, "that a constant primary galvanic current, as from thirty to fifty Daniell's elements, when directed, say through the nerve *medianus* in a downward course, produces the more pain and less extension of the limb; while if an upward current is used on the same nerve, there is the less pain and more extension of the limb; and, moreover, that while such a current is so running through the nerve *medianus*, according to the rule, and perhaps causing at first an extension of the arm and hand, there may appear in the same case, sometimes, a dropping of the hand, i. e., during the action of that same current; and this, again, may be quickly succeeded by a contraction, caused by a still further action of the same current. Again, where the electrodes are situated over the nerve trunk and its ramifications, in such a manner as to lead the current *obliquely from* the flexion side of the limb *to* the extension side, even if with a less current, there appears to be more effect than a stronger current produces when the current is directed so as to meet the nerve fibrils from without, inwards. And, again, while it is true that the skin offers a certain degree of resistance, still are we compelled to believe that the sentient nerves participate in the results that at first sight might be ascribed solely to the motor nerves; and, finally, that under certain circumstances, it requires but a relatively small fibre, nerve, or central excitement, to change a simple current closing *twitch* into a true *tonic contraction.* Electro-tonic contractions do sometimes appear to set in, without the participation of the sentient nerves, or of the central organs; but they manifestly more generally come from *joint effects* on the sentient and motor nerves, being manifested not only in the reach of the nerves excited, but also in the antagonizing muscles; and this phenomenon cannot be satisfactorily explained in any other way. The central in-working of the constant

current, as appearing from the foregoing, and so far as made apparent by the galvano-tonic contractions, might be ascribed by some to the production of a variable sensation of *pain* in some cases; but pain in other cases does not at all appear."

Dr. Remak says his own experience has led him to view this class of results produced by the current, in the muscle fibres and through the nerve fibrils, as proceeding directly through and from the central organs, entirely independent of any pain excited by the current; and that there are also some other clear cases of galvano-tonic contractions, whose origin is exclusively central. To illustrate this he mentions the case of a woman who had been suffering for eighteen months with a complete hemiplegia of the right side, together with a total loss of speech, the results of an *apoplexia cerebralis* which attacked her in childbed. But after mentioning the various treatments she had received, without any good results, he then proceeds to say that when he caused a steady current of from twenty to thirty Daniell's elements to be directed through the nerve *cruralis*, or its cutaneous branches, there appeared, after twenty to thirty seconds, involuntary movements of the palsied hand and fingers, that continued as long as he retained the application. Then, again, the same effects were produced from a similar treatment of the nerve *ischiaticus!* These effects were evidently not temporary, but enduring, from the fact that the patient re-acquired by degrees the natural influence of the will over those extensor muscles of the leg and arm, which up to that time had been totally paralyzed; and this bettering was all the more noticeable, as he, from time to time, called forth contractions in the arm from galvano-tonic reflex action "*by an up-running current through the nerve ischiaticus* — alternated sometimes also with the current run in the usual manner on the arm itself." He is of the opinion that this kind of battery in-working, through the thigh nerve, is of real and all the more *peculiar influence* for good, from the distance and direction of the thus produced reflex motions through the motory apparatus and powers; as shown, too, by the control the central organs afterwards permanently obtained over the palsied limbs.

Another important fact, that is obtained by him, both from these trials and from the treatment of many cases, which is a gain for therapeutics, is this — that a constant primary current, of a supportable and reasonable strength, directed through the nerve trunks and muscle fibres by means of metallic electrodes with wet coverings of buckskin or cloth, applied to the skin of a healthy person, *is far from producing any sort or kind of "palsying" influence whatever;* but, on the other hand, the *increased excitability* of the affected parts from the working of the current becomes perceivable in the *sentient* nerves, as shown by increasing pain ; and under favorable circumstances, is shown also in the *motory* nerves by tonic contractions. If, therefore, it is almost impossible to derive, by means of the constant current through wet covered metallic electrodes, any other than the more vigorous actions of the muscles through nerves, it is clear that a *down-toning* or *paralyzing effect* is only to be expected or obtained under the conditions by which M. Matteucci tried to accomplish it, viz., by means of wet strips of linen used as electrodes to let on the current in the utmost gentle and gradual manner possible, and to maintain it long, and then to take it off in the same slow and cautious way, so as to avoid producing any twitchings, or tonic contractions, by avoiding the least possible *approach* to interruptions, or variation in the density of the in-working constant current.

Here I must also mention that we should take care not to ascribe the *absence* of sensation, absence of closing twitching, or absence of tonic contraction, to the *necessary want of action in the current;* and therefore it is of paramount importance for those employing the constant galvanic currents for therapeutic purposes to always include a galvanometer, or some kind of electrometer, as the galvanoscope, in the same circuit, so as to indicate *some*, but, better still, *the precise degree* of activity of the current; or employ Garratt's graduated battery.

As a general rule, I think the *comparative excitability* of *nerve trunks*, as uniformly shown by pain or contraction, appears greater the nearer the excited portion of the nerve lies to the brain. This holds good not only as regards single nerves, but it

is applicable to all the nerves of the human organism. Even with the motory nerves it appears to be a rule that here, also, the excitability decreases in proportion as it is made farther from the brain: thus tonic contractions can be produced on the human hand with so much the more facility the nearer the electrodes are placed to the brain over the trunk of the nerve *medianus* on the upper arm.

Labile stream workings are those that are produced by means of small metallic electrodes covered with wet wash-leather, flannel, or linen, and which are either hitched along over the surface, say every five seconds or so, on and in the course of the nerve, or held *more-and-less* firmly against the skin, so as to cause in either case frequent or constant changes in the density of the current.

Stabile stream workings are those used for down-toning — i. e., for purposes exactly opposite to excitability. For this purpose we must always choose *large*, soft, and moist electrodes, which must be gently and very gradually applied, and then held with an even pressure and moderate current, and then removed again, after the time, say from one to five minutes, with the same degree of precaution.

There is a nice difference, also, to be observed between the *entrance* and *leaving* muscle contractions and the *closing* and *opening* contractions. These first, as we have seen, occur at the instant the current of the battery begins to course through the nerve and flesh; while the others occur at the instant the current is interrupted, opened, or broken, (as these latter terms are synonymously employed.) But the term "*entrance contraction*" refers to the putting on the electrode, *while* the current is still running, and the term "*leaving* contraction" refers to the removal of the electrode *while* the current is still running. On the other hand, the term "closing contraction" refers to the *closing* or making the circuit, as by the metallic switch contact of the key-board; and the "opening contraction" refers to the *opening* or breaking of the circuit by opening the same metallic key of the key-board. The latter division *is stronger in effect* than the former, probably because the electro-tonic state is more

readily induced by the very sudden change, than by the more gradual application and removal of the electrode. Therefore we obtain a rule in practice, that where we wish to *tone up*, or produce *increased excitability*, the quick, metallic making and breaking of the current is best. Also, for this, the choice of a brisk current through hard, moist, and moderate-sized electrodes is best. While, for *toning down*, the gentle putting on of the electrodes, and taking them away again after a *more lengthy* application, and this while the even current is still running, is always to be preferred; so, for this end, we should also choose the large, fine, and softest sponge electrodes, and employ the most gently managed, even, and moderate current.

We shall sometimes find that we can obtain, even from a medium *labile working*, a moderate degree of down-toning in abnormally *exalted* nerves. But we must not be too confident that the *stabile in-working* of the constant current through a nerve produces, by the induced electro-tonus, a diminishing of capability or of sensibility under all conditions and to any extent. Rather will we meet, in practice, with the more uniform facts that invite us to the view that the reëstablishment or the increase of the somewhat existing *electro-tonus* in the nerve fibrils and muscle fibres, by means of stabile currents, is the very best means for bringing the nerves into a condition most suitable for the normal or natural conduction of both peripheral and central impressions.

It is now ascertained, as I am inclined to believe, that the *current variations*, even when small, are sufficient to produce changes in the density and uniform direction of the native nerve current, and are more powerful and effectual to arouse an increased susceptibility in the nerve, for the future working of the applied current, than the *stabile* in-working acting even for a longer time. Our experience also teaches that the increase of susceptibility in a nerve, appearing at a *labile* in-working, is seen not only at the entrance and leaving of the same current, but even with a weaker current; so that, for instance, where a nerve is not susceptible to the action of a given primary current, — say from ten elements, — yet it will be made to acquire this aptitude

after a short in-working of forty, then thirty, then twenty elements, for a few seconds each, so that the nerve will now respond promptly to the ten. This increase of excitability, brought about by the current, is most easily traced, for example, on the muscle *biceps*, or on the facial muscles. We therefore lay it down as a *rule*, that a current which at first, as in cases of palsy, produces neither an entrance or leaving contraction, can be made to show it after having an in-working for thirty to sixty seconds of the same current strength, and this all the more prompt the longer the current has so worked. Indeed, very similar results as these last are obtained when, in the same manner, we use the *induction* secondary currents of *fine* vibrations as if a primary current.

From the repeated results at the electric *seance* of paralyzed patients, we find that the previous employment of say a half-quantity induction current, — that is sufficient to produce muscular contractions, although the electrolytic action of this, as shown in the galvanometer, being nearly at zero, — increases the susceptibility of the nerve and muscles for the after in-working of the constant primary current, certainly as far as that is shown by pain, redness, and twitchings at the entrance and leaving of the current. Furthermore, we find that the susceptibility of the muscles and nerves to the action of induction or Faradaic currents, and to constant or Galvanic currents, is about the same; but there are cases among healthy persons, and others still more marked among the paralytic, where the action of this current or that, decidedly prevails.

It is but a natural query, arising from many observations of Galvanic and Faradaic treatments, whether the change thus produced in the *electro-tonus* of the nerve and its depending muscles does not play an essential part in those cases where are shown the most wonderful and otherwise unaccountable curative effects of the various electric currents; although it is more in harmony with our present knowledge, and the prevailing opinions, to say that the *electrolytic* working of the current produces the restoration.

"*Volta's Alternatives.*" — We look upon these manœuvres, in given cases, as some of the most powerful means we possess for

producing an in-working of the current in the fibrils of the nerves, and, in the ultimate muscle fibres, for *increase* of excitability. Yet, according to Dr. Remak, we must always make a rigid distinction between the *excitability* of a nerve or muscle and its *capability;* for these two terms are not, in these connections, the same.

I have never as yet been able to discover any diminution of susceptibility from the moderate use of this method of using a current, as to strength, say twenty Daniell's elements, or half power of induction currents; and as to time of each alternating, say, for an average, every fifteen to thirty seconds; and as to length of *seance*, say five or ten to fifteen minutes, — so far as it was shown by pain and prickle, by contractions, and other sensations. Not only so, but there is usually an *increased* response to the manœuvres of the electrodes; for where a motor nerve is embraced in the current that did not at first show any muscle twitch, it will, after a very few turns of the current-changer, respond by strong contractions in its depending muscles, or in their antagonists. This proves M. Marianini's observation to be correct, that "the *induced opening contraction* always indicates an increased preparation for the response to the production of the opposite current." We also find that this increase of susceptibility is augmented all the more, the more *suddenly* that change in the current is produced.

"*The Tetanus of Ritter*" — so often quoted, but, after all, seen only in the *dead* frog — I believe has never been observed in living men; i. e., after employing the constant current for remedial purposes: nor is any moderate working of a current able to render either a nerve or muscle not susceptible to the entrance of the same or the opposite current. But still I believe this might be produced by an unwarrantable and abusive use of a very powerful and painful current, repeatedly applied and reversed by a metallic current-changer, if persisted in for some time. So is a *guano* island desolate; and when guano is too powerfully applied to a field or orchard, it is well known that it kills; but in that very *power*, when rationally employed, consists its undeniable fertilizing capabilities.

Polar-working of either the primary or secondary current is a term given to whatever effects are produced *at the site* of the two electrodes, at the entrance, during the stay, and at the leaving of the current. This term, therefore, covers those older terms of "convulsion pole," "painful pole," and also those changes which were produced, or rather were supposed might be produced, by a protracted application of the electrode in the same spot.

Grapengeisser, Matteucci, and Remak, particularly, state that the action of the zinc pole of the constant or *primary* current, as of Daniell's battery, is the strongest. We find that the down-running of such a current produces stronger twitching at the closure of the circuit, during the closure, and at the moment of taking it away; while the up-running current produces more twitchings and longer enduring contractions, both at the making and breaking of the current. This *rule* applies not only to the superficial nerves at the borders and surface of the muscles, — as this can be distinctly seen by trials on the muscle biceps, — but it applies also to the deeper ramification of the motor nerves, even those situated deep inside the body of the muscle.

Intra-polar workings of electric currents are those which become apparent, even in healthy persons, in the territory of the ultimate ramifications of a nerve that is being embraced in the electric current; as, for example, where the current has been applied and maintained in the contrary direction to the natural nerve-current; and thus a modification in the latter is produced.

Extra-polar working of a current is simply that which is produced outside of the direct route between the two electrodes, and which is manifested by sensations or motions not properly arising through the nerve fibrils embraced by the current. These effects are more easily traced in sentient than in motory nerves. Under this head we will call attention to the fact that any one can observe, viz., that when employing strong induction currents, as upon the nerves and muscles of the arm, if the electrodes are pressed hard upon or over the motor nerve, *it lessens the pain*, and at the same time causes the contractions to take place stronger and deeper. This is a strange phenomenon. It

has been thought by some, that the constant primary current, and also the secondary current, does not act by a true *central* reflex action, but rather by the *painful* excitation of the peripheric nerves, such as are pairing off with their fellows of motory nerves, and thus causing contractions by a kind of *local* reflex action. But if this be so, how can we explain the fact just mentioned as to the Faradaic phenomenon? According to this view, when lightly applied electrodes with strong induction currents cover the region of a nerve, then there should be more contraction, because more pain. But we see that by pressing the electrodes deep into the flesh, the pain is *less*, while the contraction is so much the greater. It cannot be an exclusive action, then, of that sort.

We find that good electro-muscular contractions are not always to be produced either through the employment of Faradaic or Galvanic currents even on the nerve trunk, or on a pure motory nerve, until its branches in the muscles themselves have reacquired their excitability by the action of the current, i. e., by the *extra-polar* working of the current, which is possible even on the motory nerves; but this is realized, probably, only under certain conditions of the peripheric extension workings produced by the current.

Polar alternatives are those alternating motions in the managing of the electrodes during a *seance*, that is simply the removal or disturbance of one electrode while the other remains, and then the removal of the latter while the former remains, and so on, either alternately, double alternately, or treble alternately; i. e., three times lifting the one, and then the other three times, &c. By such manœuvres we are enabled, by means of one and the same galvanic, or even electro-magnetic current, to expose two different muscle groups, or nerve groups, in an *unequal* labile excitement — a means of great value in a portion of cases that present for treatment. Those phenomena which appear in very excitable muscles, belong to the local workings of current variations in the nerves and muscles together, as where a current is directed through the motory nerve *peroneus*, which occasions, even at its leaving, a contraction in the depending muscles;

while a current of equal or greater strength, directed in precisely the same manner through the muscles themselves, shows no sign of contraction. If, now, we place one electrode on the muscle and the other electrode on the nerve trunk, then the lifting up of the *latter* electrode will produce contraction, while the lifting up of the other will leave the muscle still at rest; and this difference between the two will be the greater, the more care we take to produce waving or staggering of the current, just as the electrode is leaving the skin.

"*Alternations of Ritter*" may be understood by placing the two electrodes, say the one on the nerve *medianus*, and the other over the nerve *radialis*, in the neighborhood of the bend of the elbow where those nerves come nearest the skin, and then make contact from a battery of some thirty to fifty Daniell's elements, for there will appear, as a general thing, immediate contraction for flexion, which may also last while the current runs, producing a fair bending of the arm from the action of the flexors. Sometimes, however, this appears rather in the extensors. But if the direction of the same current is now reversed by means of the metallic key of the key-board, and that while the electrodes remain as they were upon the same spots, then the previous contraction, after a momentary recess occasioned by the turning of the current, appears again, (*and now with increased strength*,) or even will show it in the antagonizing muscle groups. Now, in case this latter result obtains, if the current direction be changed again very suddenly, as before, then the previous contraction comes in again, and this "alternation" appears so much the more readily in proportion to the suddenness and frequency of the changed directions of the current. Occasionally these results do not appear until after the changing has been repeated several times. Sometimes, moreover, these alternations of the current are attended with contraction of the flexors from the up-running current, while the down-running current produces contraction in the extensors; and this order of events follows the regular turnings of the current.

Labile workings of primary, and also of secondary elec-

tro-magnetic currents, can be most easily produced by *changing the position* of one or both the electrodes up or down on the nerve course, or over the muscle fibres, so as to increase and diminish alternately the distance, and hence the amount of substance and resistance there is *between* the poles. This, I find, often proves actively remedial, even where it does not cause any visible contractions; and that too, sometimes, where very active convulsive twitchings had been repeatedly produced in the same case previously by "hap-hazard" magneto-electric treatments, that were attended with no durable improvement, but perhaps only with a diminishing of the little voluntary capability that before remained; also, where *stabile* primary currents, of equal strength, refused to act.

Labile contractions are those which are produced in the muscles, or in the muscle nerves, simply by variations in the density of the electric current that passes through a given fibre, or group of fibres, or twig of nerve that ramifies the fibres, (but without actual interruption,) according to the *law* laid down by M. Dubois-Reymond, namely, that a muscle responds by contraction not only to the interruption of the current, but also to a variation of the current. These labile contractions can, therefore, be produced when, from the effects of the current, the nerves and muscles have acquired a certain degree of excitability, and if we then give to one or both electrodes the least move, or by gliding them along a little without actually removing either of them from the skin, the muscle fibres over which the moving electrode approaches go into contraction, while those other fibres of the same muscle, or other muscles that the electrode leaves, at the same time cease to contract. If, now, the button-like electrode, that is covered with wet cloth or wash-leather, be moved along in a wavy or undulating manner *over the course of the nerve*, then all the muscle fibres depending on that nerve will be affected; i. e., if they are in a state of sufficiently high excitability. Those fibres near by and immediately touched will also be influenced, but in a less degree. On the whole, the working will often *appear* to be the strongest in the muscle fibres themselves. We can produce analogous *labile* excitement in the

nerve trunk that occasions tonic contractions of varied degrees, according to the resistance the given current meets in its way. Labile contractions can also be produced by directing one electrode so as to glide over the point of insertion of the tendon into the *farther end* of the fibres of the muscle.

We are led to notice that, for instance, in lean persons, when the *platysma myoides* is caused to contract by Faradaic or Galvanic excitement, the skin of the neck is raised into sharp folds, over the contracted fibres of that muscle, from the *transversal* arrangement of the electrodes above the clavicle. Now, as soon as one of the electrodes is swept along, we get the labile contractions in the successive fibres over which it passes. But the contractions are still stronger if the electrodes are situated so as to be according to the anatomy of that muscle; i. e., longitudinal with its fibres, if the electrode movements regard that mainly, although obliquely. In such muscles as are attached fleshily to the bones of the joints, the mechanical effect of the current is almost nothing when the electrode passes transversely across the fibres of them. But we can increase this effect, as, for instance, on the extensor muscles of the relaxed and downhanging hand, *by a proper position or support, as of the forearm*, so that the current will then simply, from that little aid, produce a full lifting of the hand to a horizontal posture, while the electrode moves along rather obliquely across the direction of those extensor muscle fibres on the forearm, and thereby changing even the *labile* contractions into a gradually increasing tonic together-drawing of the fibres of the extensor muscles, and thus producing a good stretch of the hand.

Sometimes we notice the labile contractions of the contractile tissues and muscle fibres will appear *only* at the moving, and not at all at the stationary electrode. This is according to the excitability of the contractile fibres that come respectively under the electrodes. If the trial is reversed, i. e., if the previously moving electrode is now held at rest, while the other one is caused to vary and move a little, then, even, will the very same fibres twitch which are under or near the electrode that is at rest. This can be tested in another way on a large scale, as

with whole muscles or nerve groups, if we place one electrode, for instance, on any point of the upper or forearm we choose, as on the nerve *medianus*, while the other electrode is made to move over the nerve *radialis*, or its motory branches in their muscles. The flexors will at first remain at rest, while only the extensors will get into a state of labile movement; i. e., after a time, when they have acquired a sufficient toning-up from the current stimulus, (which, however, sometimes fails to occur,) but which can be easily ascertained by a reverson of the trial. Even in cases of nerve and muscle sickness, and where the extensors are deprived of all voluntary capability, neither are able to be excited more by localized Faradaic currents directed to those muscles, still will their *labile* excitement, under the same conditions, bring about a contraction in the antagonizing flexor muscles, and this simply because the flexors were in that case already more susceptible to the influence than were the extensors. But even where the excitability of two groups of nerves or muscles, as, for instance, those of the flexors and extensors of the well-rested and healthy forearm, — as far as it can be ascertained by the application of a similarly directed and equally strong current, that shows at the entrance, and leaving no remarkable difference of result, — even then will every directed current by a *uni-polar* moving electrode, which embraces those two nerve groups or muscle groups, leave at rest the parts that are in contact with or near to the stationary electrode; but at the same time there will be produced within the reach of the *moving*, staggering electrode, visible labile contractions. M. Remak finds from his practice, as well as from his pre-trials, that the primary current of galvanism possesses, through a varying density, a kind of working that reaches the blood vessels that radiate through the muscles, causing them to enlarge and contract alternately, so as to produce a visible swelling of the muscle fibres themselves, and *increasing their endosmotic capability;* in which respect, he says, the primary constant current differs from the induced secondary current of Faradaism, for this latter, he thinks, *decreases* this endosmotic capability, whenever it is long or often "*actively*" applied. For, he says, as soon as

the muscles are under an abnormal central influence, we see there is a state and action produced in the ultimate fibres, that leave behind a lasting electro-tonus and muscle stiffness, exactly the same as can be produced where it is not already in the patient, *by the too active use of electro-magnetism.*

Judging from all electro-therapeutic experience, we are led to conclude that the so-called constant or primary current of galvanism can place the nerves of a given case, even after an almost *stabile* in-working on them, in a condition most favorable for the exertion of the voluntary influences of the will; or, in other words, to convey the natural messages of volition; and this, in plain words, means *to reëstablish the lost capability for normal action.* This constitutes *the cure.* Furthermore, we find that, for instance, in one portion of the cases of atrophy, the wasted muscles can certainly be plumped and rendered more firm and warm by the occasional practice in them of *labile* contractions. But this increase in size is seen to be limited to those fibres or portions of the muscle which take on this response to the action of the current; from this it is quite apparent that the enlarging or growing of the muscle fibre groups is produced by an actual absorption of liquids along the sides of the muscle fibres, whose endosmotic capability has been thus increased by this current, or method of using it. The same can be done, but with more difficulty, by means of well-managed electro-magnetic currents.

By-workings of the current.—Under this head, and with all due deference to the views of Dr. Duchenne, we should first state our profound conviction that it is impossible to be quite sure of ever *limiting* the effects of any Galvanic or Faradaic currents to a single nerve or muscle only. Rather is it apparent in practice, that in every case a more or less simultaneous excitement of both the sentient or skin nerves, and of the motor or muscle nerves, as well as of the neighboring contractile tissues also, is unavoidable; to say nothing of central reflex-action, which some of the most experienced and distinguished electro-physiologists and therapeutists also claim as a uniform result. The influence of the applied current, we find, will spread sometimes more, sometimes less on either side, as well as beyond, the straight

line between the acting electrodes; and this seems to take place all the more through the adjacent and more moist tissues, the longer the current is kept in action at one spot. Where we are working a current over a nerve trunk, or the muscle, the only way almost that I have found to determine whether the stream is capable of gaining the proposed end, is to test whether the interruption of the current excites any contraction through the *motory* nerves. In many cases we find the evidence of good in-working through the *sensitive* nerves, by an eccentric sensation, which is a sign, whether *all the radiating fibrils* of the nerve are excited in an equal manner.

There are a very great number of by-workings of the primary current that are not so important. There is, however, an effect of this kind whenever an active current is applied about the head or neck, which causes flashes of light, dizziness, silver taste, or sound, besides a tendency to tilt the head over towards the removed electrode, for it is not during the steady working of the current that these results obtain, so much as at the putting on or taking off the electrodes. These effects are to be avoided, i. e., not to be often repeated with strength at once, as a mere experiment, but nevertheless are to be observed in practice as valuable *evidence of sufficiency of current for the given case*, and that the action of the current is certainly going on.

By-working of either primary or secondary currents on the heart is rarely produced; indeed, I can say that I have never as yet seen any kind of such effects, either in healthy or sick persons, from any of my ordinary rational applications, such as are required in treatments. But I would never risk the trial very powerfully, either for experiment or for treatment.

There are not unfrequently kinds of *after-workings* of this current in well persons, and in sick persons also, which should be mentioned. In one case, perhaps, several hours after the *seance*, there will be sensations in the joints very similar to those produced at the time, by the in-working of the current; in another patient, there will be the silver taste often repeated; in another, there will be sensations like those from the vibrations of induced or secondary currents; in others, a prickling in a

distant part or limb, which, perhaps, shows itself repeatedly; or there is a glow, or even a perspiration, where the skin has before been peculiar for its dryness. In other rare cases there are even automatic movements of particular muscles, or groups of muscles, that are repeated from time to time. Now, whenever any of these phenomena occur, we can rest assured that, whether the patient is benefited by our treatments or not, the needed degree of profound electro-nervous excitability is certainly not wanting.

Messieurs Becquerel, Dubois-Reymond, and Remak, are severally of the opinion that the properly managed primary constant current of galvanism can produce good and effective service in spasmodic diseases, not because of the paralyzing effects, nor from that tendency, but, says the latter, "because in certain cases *it restores to the central organs their power of dominion over the actions of the nerves and muscles*, the want of which produces or *allows* clonic spasms and cramps; in other cases, because it removes, by electrolytic in-workings, the peripheric or central irritation, where such is possible, through which many cases of spasmodic conditions are produced, and maintained, often, until the organism is self-destroyed."

In some eminently practical observations, Dr. Remak further says that, on account of the great variations in the excitement of the motory and sensitive nerves of patients paralyzed from *central*, or even local peripheric causes, it is absolutely necessary for the physician who proposes to apply the *primary* current of galvanism, as a remedy, to be first well equipped with every facility necessary to give him *a perfect command over the current* as to strength, the varying of its intensity, interruptions, reversing its direction, and as to electrodes of different sizes and material, as also the simultaneous and similar command of an ample induction or Faradaic current. He needs these, he says, at least, to work up the sunken excitability of the nerves, so as to produce powerful contractions, and, at the same time, not to torment the sensitive nerves, nor yet to fatigue or exhaust the muscles. He mentions that he has found the current-changer of the key-board of great use in clearing away the tonic contractions of paralysis, and of old rheumatisms. He says such con-

tractions are not relieved by an exclusive excitement of the once antagonizing muscles now paralyzed, nor of the muscle nerves. He then urges, in this connection, how little use is the mere local excitement of the muscles, and the nerve branches that are among the muscle fibres, in all those cases where the excitement of the larger nerve trunks is in effect, at least for the time, utterly lost. On the other hand, he shows the real curative effects of localized Faradaic treatments in those cases where the excitability of the large nerves is truly *diminished*, but not entirely gone as in lead palsies, for here we find the excitability of the branches in the muscles quite gone. Even in some cases of "progressive muscular atrophy" he found the excitability of the nerve trunks less than the ultimate twigs that were in the muscles, although then far wasted by the progressive palsy. He here recommends, therefore, first of all, and in every case, to ascertain and define, for one's own mind, the exact amount of excitability of the nerve trunk, and then proceed to the restoration, now in this, and then in the central direction, as we may find indicated, or to give the best results.

The degree and extent of the true electro-muscle excitement, according to the results of comparing trials, appear to be *in proportion to the sum of the motory nerve branches or fibrils that are embraced by the current* — i. e., that lie under, near to, and between, the electrodes. Dr. Remak interprets the weak or partial surface-workings of the electric current, from being applied along the course of the muscle fibres, as only the consequence of an excitement of the few superficial nerve twigs embraced, and which he terms "*extra-muscular action;*" while the deeper total muscle-workings of the current, which are produced when directed into the muscle by its largest nerve trunk, he terms "*intra-muscular action.*" Dr. Duchenne terms the former, as we have shown, *immediate*, or "*direct, Faradaization;*" and the latter, *mediate*, or "*indirect*, Faradaization," for, as we have also said, Duchenne believes in the Hallerian irritability. Remak believes that nerves are absolutely essential to muscular contraction.

Without giving details, I will say that it has been fairly demon-

strated that the blood vessels, including both the arteries and the veins, of the thigh of a living animal, as of a frog or rabbit, which has been subjected to the immediate action of a very "*strong* current of induction" for some ten minutes, do then actually dilate. It has been thought that we are therefore justified in expecting, at least, with this temporary enlargement of the vessels of the muscles, a proportional increase in the supply of blood and nutriment from such treatments. But the nature of this dilatation of the vessels is a question to be considered. When a *weaker* current is brought to bear upon the muscle, and for a shorter time, and that through the *border point*,—which means, simply, through its motory nerve,—it is equally certain that the blood vessels are both dilated and contracted by the different influences of the current. Therefore the intramuscular excitement of the nerve fibrils and muscle fibres, as well as the vessels through the *border spot* or nerve, is always preferable, or, at least, is less objectionable, particularly wherever we wish to avoid those undesirable motory or sensitive by-workings which generally accompany the excitement of the larger nerve trunks. We know we can contract and momentarily tetanize the facial muscles as a whole, in groups, or singly, and that without causing much pain from the nerve trunk of the *portio dura*, or its large primary branches.

Drs. Duchenne and Remak have both of them Faradaized the diaphragm of man, the former operating through the *phrenic* nerve. The latter says, "The diaphragm seems to be a participator in the acts of respiration even more than any other of the thoracic muscles, and is susceptible to immediate electric excitements. I have produced by Faradaic currents, on some healthy young men, instantaneous, violent, and painless contractions of the diaphragm, which were indicated by the vaulting of the abdominal parietes on placing one electrode 'in the pit of the stomach,' while the other was on the most prominent curvature of the seventh and eighth ribs on the right side. It was interesting to observe the phenomenon while the currents were retained there, for, immediately after the current was applied, the tonic contraction (which was inferred from the arching of the abdomen)

ceased, even while the current was still running. This was then gradually succeeded by a to-and-fro flapping of the parietes of the abdomen, and at the same time these persons expressed a conscious feeling of hickup. This clearly proved that the diaphragm was assuming its natural rythmatic contractions, even in the midst of the action of the electric currents, and while struggling with them. When the electrodes were removed, the diaphragm took on its normal functions."

The rule is then obtained, that in order to electrize the muscles truly, methodically, and at the same time beneficially, either by Faradaic or Galvanic currents, we must become familiar with the bifurcation of the nerves, which is synonymous with the "*border points*" that simply mark the entrance places of the large nerves into the muscles. This knowledge is most readily obtained from experience in practice, and from trials on healthy persons; or on very recent subjects, as can be done only in hospitals or almshouses. Since the motor nerves almost invariably enter the muscle on its sides, we will, in doubtful cases, or if but little experienced, or in such as where the immediate affection of the nerve is, on the whole, not probable, act more judiciously by moving the metal *ball electrode*, covered with wet wash-leather, along the borders of the muscle, back and forth, until the spot is found and manifested by a good contraction, than by simply resting large sponge electrodes any where over the muscles, and regarding only the muscle fibres, according to the method of Dr. Duchenne.

The operator, although inexperienced in all this, will soon discover that he can produce a together-drawing, or contraction, of the muscle *biceps*, for instance, or of the muscle *deltoides*, or of the muscle *pectoralis major*, far easier by applying the one *small* and *wet* electrode to the spot of nerve entrance, and with the other so situated as to direct the electric stream lengthwise and somewhat obliquely across the muscle, than if he seeks to act only with reference to the long direction of the fibres of the muscle. I need hardly remark that in cases where the revival of paralyzed muscles is sought for, we then more especially must choose those points for the site or nucleus of wavy movements for one

electrode, which, by trials on healthy persons or on the very recent subject, are shown to produce the most prompt and powerful effects. By this method, then, we succeed more surely, use less current, accomplish more in less time, and occasion less pain; and in the more doubtful cases of apoplectic paralysis, we also avoid any great degree of hazardous excitement of sensitive nerves, which will yet be more generally acknowledged to produce a uniformly greater or less degree of reflex action.

We have learned from Sir Charles Bell, as well as from our own trials, that the muscles do not distinguish between the sensation of heat and cold; and, besides, every surgeon is familiar with the fact how little pain the muscles experience when being cut through; yet it may be possible to produce pain in muscles by means of the electric excitement. Dr. Duchenne observed that the electrization of raw muscle surface in a wounded fleshy patient produced only a dull kind of sensation, but no actual pain. I have already spoken of the manner in which large muscles can be brought into a painless, active contraction; and these form no exceptions, but are rather the daily experience in my practice.

Dr. Romburg, in his learned and excellent work on Nerves and their Diseases, distinguishes two great classes of conditions of the sensitive nerves of muscles — the one *hyperæsthetic*, the other *anæsthetic*. The normal shortening of the muscles during movements of the members takes place, it is true, without causing much, if any, sensation. But we learn further, from M. Weber's researches, what part the muscles take in the sense of *feeling* of tension, as when carrying burdens, as also in the pains we feel during cramps in the calf of the leg, during inflammations of the muscles, &c.* Now, this is a difficult question to solve, whether in all these cases the sensation experienced proceeds from the abnormal state of the muscle fibres themselves, or from their surroundings of sheathing tissues. According to the researches of Dr. Remak, the tendinous prolongations of the thin, flat muscles, as of the diaphragm, the *latissimus dorsi*, of

* Ludwig's Physiology, vol. i. p. 360.

the eye muscles, and others, present to ocular demonstration numerous nerves of medium size, composed of such fibres as led him to believe that they are none other than nerves of sensation. I have frequently demonstrated on healthy young men, who were my students, the possibility of managing the electrodes, even with a moderate current, so as to bring the *depressor anguli oris* to a tetanic contraction without causing the least feeling, as they themselves stated.

A man presented for treatment, or rather for advice as to the expediency of the electric treatment, whom I found to be afflicted with true apoplectic paralysis involving the *portio dura.* When testing the nerves and muscles of the face very gently, we found a small branch of the nerve *supra orbicularis* to run within a very trifling distance of the *border point* of the muscle *frontalis;* that is, from the entrance-spot of the motory nerve into that muscle. The two points are not half an inch apart; yet when one is touched by the electrode it occasions pain; when the other is touched there is a complete contraction of the whole muscle. The other muscles of the face are very similarly related, and for good reasons. It is thus that we discover, even on the smallest muscles, this pleasing result: that the currents of Galvanism, or of Faradaism, whose application insures the most powerful effects through the motory nerves — which are manifested by contractions — are also often the very ones that are productive of the least sensation or pain.

The operator, after all, cannot entirely avoid the sentient nerves. It would, therefore, be really desirable to have some means of uniformly avoiding or alleviating this annoyance and real drawback in electric treatments. Dr. Duchenne recommends the bringing of the two electrodes together before applying them to the skin. This is well to be remembered. We may (as is my own method) also apply the electrodes first, and then introduce the soft iron within the helix very gradually, while using Faradaic currents; or if Galvanic currents, begin with the switch on a low key, or no key, and then by running up the scale until the number of batteries is indicated by the produced prickling sensation.

Where the smaller branches of sentient nerves cannot always be avoided, and as the fine plush of skin nerves is every where present to greet the electrode, I usually employ a *strong pressure of the electrodes on the skin, to lessen the skin sensation* and pain; and this proves a most effectual means, as can be tested on the forearm or on the *interossei* muscles. Patients usually assure me that they do not feel any thing really disagreeable; and yet perhaps the muscles are in full play from the influence of the current. Others say that the sharp prickling or burning sensation produced by the too light or careless application of the moist ball electrode ceases as soon as it is more firmly held; and then in its stead there comes a dull, but more supportable, deep-seated, indescribable sensation. It is necessary at the same time not to make the pressure too great, for this will increase the pain rather than diminish it, not only from the pressure itself, but by conveying the current to the *periosteum* of some underlying bone. It is also important and necessary ever to give the parts we wish to operate upon a firm and easy resting posture, such as will also make the *border point* of the muscles accessible, where it is possible to be done. Nor must we be too ready to remove or incessantly slide the electrode this way or that on the skin, unless it is to avoid a painful sentient nerve, or to move to, or more surely fix upon the exact spot we have been led to believe is the most suitable. The better way is to choose the spot, and then apply that electrode boldly and firmly at once, and hold it with a steady hand from second to second, or minute to minute, or less, but never more. These directions apply, however, more especially to the treatment of paralysis. (See p.478,C.)

My advice is to commence with throwing aside the awkward yet every where provided and used metallic electrodes or "handles," as they are called. The custom has been to hold these in the hands, or to stuff wet sponges in their outer ends, and thus apply them to the body, or else drop one of them into a bath tub, together with the feet or hands. But all this is unphilosophical, hap-hazard, and, in plain words, sheer empiricism. It is better to make use of fixed insulating electrodes provided with metallic oval ends or surfaces, that vary both in form and size. Of these,

some should be covered with large and very fine sponges; others with very small; while others should be covered with thick wash-leather; each must be thoroughly wet or moist (as well as scrupulously clean) when used. The moisture employed may be water or salt water. In my own practice I use pure water exclusively for the last moistening of the electrode sponge or leather.

I employ in anæsthetic and paralytic cases three sizes of metallic oval-shaped electrodes: the first is half an inch in diameter; the next is one inch; the next is two inches. For the *interossei* and other narrow places, I have others wedge-shaped, so that they can be easily crowded down between the phalanges; and these are very useful, also, where the nerve trunk lies deep, and we wish to bury the current-giver deep into the thick flesh. Such electrodes are preferable for cases of paralysis, and wherever there is nerve or muscle anæsthesia. But for almost all kinds of hyperæsthetic cases of nerve, joint, or muscle affection, then the broad, soft and moist sponge electrodes are rather to be chosen. Success in this practice greatly depends upon these nice points. Mr. Thomas Hall, the electrical instrument maker of this city, has made for me, and other physicians and surgeons, a great variety of very handy and useful electrode instruments of this sort. (See Chapter III.) Thus I have endeavored to give here the *general principles* and some of the *minutiæ* to be observed in managing the *electric sitting* of a patient; but other very important *rules* will be found in Chapters III., IV., VI., VII., VIII., and X.

Other Methods for using the Induction Currents.

Dr. Duchenne, of Bologne, is unquestionably entitled to the honor of having first of all introduced into medical practice the excitement of single muscles, or muscle groups by electric currents. The precepts, however, which are contained in his large work on the method of application of "localized electricity" appear far from being sufficient, either in number or explicitness. Dr. Duchenne, we observe, distinguishes two classes of operations; first, the *mediate* electrization of the muscles, through

their nerve trunks; second, an *immediate* electrization, i. e., applying the electrodes directly to the single muscle, or bundle of muscles. The electrodes are in every case to be placed as near to each other as possible, while each of the two classes of electrizations requires otherwise different management. The technical terms he employs on page 47, to designate his particular method are, *direct muscular Faradaization*, *and indirect muscular Faradaization*,—which consist in causing every muscle or bundle of muscles to contract singly, by placing the moist electrodes, or *excitors*, as he terms them, on those points of the skin "which correspond with the surface of the muscle to be Faradaized." Nothing, he says, is easier than this way of Faradaizing, especially on the surface regions of the body and limbs, when the operator is acquainted with certain anatomical facts; but that it is more difficult with respect to the deeper layers of muscles, although almost all of them can be reached at certain places by direct excitement. The excitors should always be placed on the fleshy part of the muscles, but never on the sinews or tendons of the muscles. To Faradaize a muscle completely, it is necessary to embrace the whole surface of it by the excitors. The current must be strong in proportion to the thickness of the muscle. "As the wet excitors touch only the outer surface of the muscle," says Dr. Duchenne, "and as the nerve cords reach the muscles of the upper surface regions only by traversing through the lower surface, we feel confident that the contractions of muscles are not produced through the help of nerve cords." But the direct Faradaization of the facial muscles is very difficult, on account of the there numerous nerves; but after all he thinks it possible to avoid the latter, by simply moving the excitors gradually along in the direction of the muscle fibres.

These precepts and methods of Dr. Duchenne show plainly that he rests on the supposition that it is possible to make the muscles contract without the intervention of their nerve fibres; but perhaps not exclusively so: at least he does not follow or confine himself to his own prescribed rules; but at the end of the chapter just alluded to, he says we must not think it enough

to know the rules there given, and to be an anatomist in order to be able to produce the contractions of single muscles, or bundles of muscles, but that there are a number of details into which we must be initiated, the description of which he cannot, however, take up as yet, for by so doing he would overstep the limits he was obliged to lay down for himself. Then, again, he says there exists in every muscle an anatomical *point*, on which the excitors are to be placed, if we wish to obtain a perfect contraction. It is also often necessary to give to the members a certain position, for the electrization to succeed. For an explanation of these, he proposes to give his attention as soon as he finishes his electro-physiological researches. It is now five years since that work was published; but no such maps, charts, or explanations have as yet appeared. It is to be regretted that such statements, so replete with suggestive interest to medical practice as well as to science, made by one so competent, have not been more fully elucidated.

Faradaization.

This term originated with Dr. Duchenne; and I now proceed to give an account of his "*method*" of using *induction currents*, as explained in his large and popular work, *De l'Electrisation localisée, et de son Application à la Physiologie, la Pathologie, et la Therapeutique*, Paris, 1855. He first states, "that if the skin and the metallic electrodes are both perfectly dry, then the currents of induction do not penetrate into the subjacent tissues, but reunite on the surface of the epidermis; and that in this case there are produced *sparks*, (!) with a special crepitation, but no physiological effects." Now, we must mark this statement of his, for evidently he is employing a machine for producing induction currents, such as we never think of employing in this country for medical purposes. His method and rules will not therefore always apply to us, nor shall we be liable to meet with his mishaps, nor yet, perhaps, with his marvellous cures.

It may, therefore, be laid down as a rule, first of all, that

the electricity which requires a given rule and regulation for its employment, as also those physiological and remedial results that are brought about by any prescribed method of use, are *determined, in part at least, by the kind and efficiency of apparatus used to provide the given electricity.* This proposition may be transposed thus: A correct *rule* for using one kind of electricity does not always necessarily apply for the use of another electricity, whether it relates to the kind as static or dynamic — to intensity or quantity — to Galvanic or to Faradaic electricity — to constant, inconstant, or alternated currents; nor will there follow the same safety or danger, failure or success. With our eye on the *kind* and *power* of current employed by Dr. Duchenne, we will proceed to pass in review his leading propositions and *modus operandi.*

When dry excitors are applied to the skin that is also dry, he says, there is produced a sensation of heat or burning only; but if the skin is likewise thick, then there is no kind of sensation. If, then, the electrodes are wet, or the skin is wet, neither spark, nor crepitation, nor sensation of heat is produced; but a phenomenon according to the position of the electrodes. If they are planted over the body of a muscle, then there is a contraction of that muscle, or at least of the superficial portion of it, together with a sensation that is not peculiar to the skin, but that always more or less accompanies the electro-muscular contraction. He defines this sensation as being like that produced by acting on a muscle that, for example, has been laid bare by a wound, so as to be no longer covered by the skin.

Again, if the electrodes are positioned over the course of a mixed nerve, then contractions of all the muscles animated by this nerve are produced. Hence the proposition for his two grand different methods of proceeding: first, by applying the electrodes directly to the body of the muscle; second, by applying them rather to the nerve trunk that animates those muscles. The first method he designates as "*direct muscular Faradaization,*" the second method as "*indirect muscular Faradaization.*" In both cases he directs that the electrodes and the skin should be wet. For this purpose he employs mostly large wet

sponges, which are in part stuffed into the ends of hollow metallic cylinders, or handles, which are insulated on wood. But for limiting the electric force to and in a muscle of a smaller size, such as the *lumbricales*, *interossei*, or muscles of the face, he employs "small conical electrodes," which he more frequently terms "*excitors*," but which are simply *poles*, or *electrodes*. These should always be covered with wet leather, as buckskin, or with moist sponge. Very recently, Dr. Duchenne has observed that if the electrodes are applied to certain *spots* on the skin, the contractions of the muscles are much more surely and easily produced than if the excitors are applied to other points on the skin; and these places he has termed "*points of election.*"

But it was left for Dr. Remak, of Berlin,* to point out, and for Dr. Ziemssen to demonstrate, clinically and anatomically, those defined spots, which are found to correspond with the points of entrance of the motor nerves into the lateral borders or *edges of the muscles*.† The latter marked upon the skin of the patient, with nitrate of silver, such lines and spots as proved electro-muscular responsive,—to the there placed electrode,—and then, after death, by dissecting the motor nerve branches to their entrance into the bundles of muscle fibres, he thus found that these two series of experiments agreed with each other perfectly, in every respect. Hence Remak and Ziemssen are both of the opinion that there is no muscular contraction by exactly direct localized electrization of the muscles, as Dr. Duchenne claims, but contend, on the contrary, that in every case the contraction is brought about by the interposition or coöperation of the muscle nerve.

Dr. Duchenne remarks that to practise muscular Faradaization, both direct and indirect, requires exact anatomical knowledge of the position of the nerves. In the arm, for instance, the electric stimulus can be limited to the *median nerve*, on the inner and inferior third of the humerus. It can be limited to the *ulnar nerve*, on the space between the olecranon and the internal condyle. The *radial nerve* is accessible to the electrode at the

* Uber methodische Elektrisirung gelahmter Muskelen, Berlin, 1856.

† Die Electricitat in der Medicine, Berlin, 1857.

junction of the two upper thirds of the humerus with its lower one third. The *musculo-cutaneous nerve* may be reached high in the axilla. On the thigh, we may reach the *crural nerve* in the groin, just outside the femoral artery; the two *popliteal nerves*, in the popliteal space under the knee. The *sciatic* nerve is accessible most perfectly (but most inconveniently) within the pelvis, i. e., through the posterior wall of the *rectum;* on the outside, also, just back of the great trochanter, and between that and the *tuberosity* of the *ischium*. This latter is the more usual spot chosen.

The trunk of the *facial* (*portio dura*) *nerve* can be reached from the external opening of the ear, or after the nerve emerges from the stylo-mastoid foramen just under the ear, by placing one electrode between the *mastoid process* and the *condyloid process* of the lower jaw. But he thinks neither of these ways should be resorted to in cases of paralysis of the portio dura, because from that point in the ear the feebler currents produce no effects on the muscles of the face; while if we employ requisite currents to produce an effect on the face muscles, the electric stimulus is then inevitably conveyed to the superficial *temporal*, or to the *auriculo-temporal nerve* from the third branch of the *trigeminal* (*tri-facial* or fifth) nerve; whereby a very annoying pain is also produced. He, for that reason, advises seeking the nerves that branch from the *portio dura*, where they emerge from the parotid gland; or else limit the position of the electrodes to the individual muscles that are affected. He says he finds a slight difference in the exact situation of some of these face motor nerves, in some persons, but that the electrodes will soon discover them.

In the *supra-clavicular* region, the electrodes, if placed directly over the collar bone, act on the *brachial plexus*. If placed on the summit of the *supra-clavicular* triangle, they are then over the external branch of the *spinal accessory nerve* of Willis. The *phrenic nerve* is reached on the anterior surface of the *scalenius anticus*.

Dr. Duchenne also maintains that both nerves and muscles possess very different degrees of *excitability;* and for that reason

it is necessary to adjust the strength of the current *to the given excitability* of the nerve and muscle to be treated. He also mentions a difference of *muscular* sensation in different muscles while contracting. This he termed "*muscular consciousness*."

To *Faradaize* the *skin* he recommends *three* principal processes. The first is by the "*electric hand;*" i. e., of the operator. The patient takes one electrode in the hand, and holds it during the *seance*, while the physician holds the other electrode in his leisure hand. After having dried the skin with flesh powder, the operator passes the back of his hand over the surface to be excited. A lively crepitation is the only phenomenon produced, except, perhaps, over the forehead and face, where it becomes painful. It is the advice of the author, whenever this is done, that the operator use the same hand that holds the electrode, so as to prevent the passage of so high an induction current through his own person, which is thus to himself highly injurious and unsafe to be so long continued, or often repeated.

The *second* process is by means of solid or "smooth metallic excitors," which are adjusted to insulating handles. The skin is to be dried as before; but if the epidermis is very thick or hard, as on the palms of the hands, then the skin may rather be a little moist. When it is necessary to produce a strong effect on a certain point, the excitors are held for a given time lightly in contact with the skin. These solid metallic excitors, he says, are often insufficient for the palms of the hands and soles of the feet, whatever intensity of current may be used. In such cases a bit of wet wash-leather over the face of the brass electrode will render it at once effective.

The *third* process of Dr. Duchenne is by means of the *metallic wires*, or "brush electrode"—a bundle of fine wires adjustable in the hollow end of the common electrode. The skin is quickly and more or less lightly tapped or beaten with the ends of this wire brush, while held perpendicularly to the surface of the skin. But sometimes it is necessary to retain them longer in contact with the skin, as in cases of palsy of sensation. Indeed, Dr. Duchenne recommends this for many cases of anæsthesia, neuralgia, and muscular rheumatism.

To *Faradaize* the internal ear, he advises one electrode to be on the back of the neck, and filling the ear tube with warm water, then introducing into the water thus filling the external ear, the wire tip of the primary or secondary conductor of an induction machine, and maintaining it in the midst of the water, while the current flows, but without touching the sides of the ear passage if possible, nor yet the membrane of the tympanum. But this is so difficult to be done, so disagreeable to the patient, and so ineffectual, that the author has instituted an entirely different method, by employing an *ear electrode* of ivory sponge and silver wire, to convey the galvanic current, instead of Faradaic current, in this treatment for noises and deafness, which is more practical, agreeable, and more frequently successful. See page 243.

For *Faradaizing* in partial amaurosis, loss of taste, and premature diminution of sight, he advises "the employment rather of the continuous galvanic current, because it exercises a very much more remarkable influence on these organs than can be produced by the induction currents of electro-magnetism." But how does Dr. Duchenne (and other writers who seem to take all his propositions without question) reconcile such facts, declared by himself? This is no declaration of another — no *ex parte* testimony. A late English writer testifies that he has found the best effects from the use of moderate *galvanic currents in affections of the special senses*; and yet, in the same work, he cautions against the employment of these same currents on the large nerves and muscles of the limbs, for fear of the effects reaching the brain! I cannot account for this opinion, if given from experience in practice, unless, as in the former case, — i. e., when using *galvanic* electricity about the face, — care was taken to use the smaller intensity, also the occasional, or, perhaps, more frequent interruptions of the current, as it certainly should be only so employed; while in the latter case a stronger inverse current was allowed to traverse a nerve trunk, or group of muscles, persistently for some indefinite time, which would almost necessarily do injury rather than good. To apply any considerable current of galvanism to the nerve

trunks, muscles, back, or head of a patient, and retain it there for some time, regardless of the condition of *variation*, *of density* of current, or of interruption, direction, or alternation, &c., would be a foolhardy and highly hazardous experiment. In my opinion no such current should ever traverse the part more than one minute at a time, at the longest, although repeated again and again in the same place and manner. See D, Note 3.

The *Faradaizing* of the *diaphragm* for quickly producing artificial respiration is, according to Duchenne, best done by applying the one electrode over the *phrenic nerve*, which takes its rise from the third, fourth, and fifth cervical pairs, and is to be reached on the anterior edge of the *scalenus anticus*, and just at the back edge of the middle of the *sterno-cleido-mastoideus* muscle, while the other electrode is placed at the pit of the stomach, with a down-running current. Let the electrodes be wet sponges with large surface. The *instant* they are applied, the artificial respiration is usually produced; the thorax heaves, and the air rushes forcibly into the lungs; thus by applying and removing one electrode as often as this phenomenon is repeated, it is possible to keep up a respiratory process for a time, even after death. *Perseverance* must be the motto here; for in all cases of apparent death from water, strangulation, lightning, asphyxia, from chloroform, opium, carbonic acid gas, &c., to establish and maintain respiration, *is* often found *to save life.*

For the *Faradaization* of the *pharynx*, he uses the long handle electrode with "*olive-shaped tip*," which is to be introduced into the pharynx in *median* line, while the other wet electrode is placed on the nape of the neck. He cautions against the accident of allowing the excitors to touch or rest against the lateral *sides* of the pharynx, for the *pneumogastric*, *glosso-pharyngeal*, and *spinal accessory* nerves might be touched by the current, and thus affect the vital organs.

The *Faradaization* of the *larynx* is done by means of the same olive-shaped instrument, which is passed down (without the current) as far as the posterior and inferior portion of the larynx, while the other excitor, as in the previous cases, is then placed on the nape of the neck; or it is better sometimes to be

situated outside, front of the throat, on a level with the *cryco-thyroid* muscle. Thus situated, they may receive the current gently at first, and at the same time the sponge is moved about a little. But he says the *indirect* method is easier, and often effectual. One excitor is in that case placed over the *inferior constrictor* muscle on the anterior portion of the throat, and so reaches the *inferior laryngeal nerve.*

The *Faradaization* of the bladder is advised for paralysis of that organ. Dr. Duchenne employs a kind of sound of gutta percha, which insulates two movable wires in its two channels, which is much like a double catheter. This is first carried into the bladder, and then the wires are pressed forward through the double canula, and having a spring or band for that purpose, they diverge as they advance, until their tips are widely separated. The bladder being empty, as, indeed, he advises it should be, the contact or closure of the circuit is then made, when the portion within the cavity of the bladder is moved about so as to be applied for a few minutes to all the sides of that viscus. It is then withdrawn in the reverse manner, i. e., the current is first discontinued, the adjustable wires are withdrawn within the insulating canula, and then the whole is withdrawn much as an ordinary catheter. (See pp. 398, 680, and E, Note 1.)

Faradaizing the rectum, and also the muscles of the anus for preventing involuntary stools, or prolapsus of the rectum, and for the paralysis of the *sphincter* and *levator ani*, he recommends the use of another olive-shaped excitor, kept exclusively for this purpose. While the one electrode is within the rectum, let the other be on the skin near or over the circular muscle fibres, if the patient can bear it. He advises the precaution of first clearing the rectum by an enema, before the operation. Besides, the instrument *excitor* should be well insulated, except at its olive tip, as the *margins* of the rectum and sphincter ani are most exquisitely sensitive to any electric excitation, and therefore will otherwise produce unbearable tenesmus. This is always to be very carefully avoided.

Electro-Chemical Bath.

Sir Humphry Davy observed, as long ago as in 1807, that if he immersed his fingers in a glass vessel filled with distilled water, connected with the *negative* pole of a galvanic battery, alkalies were excreted from his body and deposited in the pure water; but if the positive pole was in contact with the water and fingers, then phosphoric, sulphuric, and hydrochloric acids were deposited, and could be detected in the distilled water.

Electro-chemical baths, known as "Dr. Vergenn's," and which figured in all the country for a while, were but the hasty result of an IDEA, put forth to the world by M. Poey, who relates the origin, treatments, and consequences. It seems that in 1852, a man occupied with electro-silver plating in the city of New York, having had his hands in a solution of the nitrate and cyanure of gold and silver, a severe ulcer was produced, which proved very obstinate of cure under the most active remedies. At last the patient plunged his hand into the electro-chemical bath, at the positive pole, that was being employed at the time for silver plating. After holding it there for a quarter of an hour, it was found that the metal plate connected with the negative pole was covered with a thin layer of gold and silver. Then, by a few more such applications, repeated day after day, the electro-chemical bath proved sufficient for the cure of the ulcer. Upon that hint was based an idea which soon grew into an hypothesis of great magnitude.

Dr. Poey, of some southern city, soon prepared a paper on the subject, which, in 1855, was laid before the French Academy in Paris, in which he asserted "*that it is possible to extract metallic substances out of the human body by the aid of electricity*,—whether such poisons had been taken as remedies, or had been lodged in the body by absorption from exposure in some of the different arts and trades."

The electro-chemical bath is administered as follows: The patient is placed sitting upon a bench of wood, which is fixed low in a deep and large metallic bath tub; all of which is in-

sulated from the ground. The tub is then filled with warmish water until the patient is up to the neck in it. If it is supposed that the patient is poisoned with mercury, or with silver, or gold, then the water is acidulated with nitric or hydrochloric acid; but if lead is to be extracted, then sulphuric acid is added to the water bath, in the place of the other acid. The galvanic electricity must be large, both as to quantity and intensity, and the long-continued, even current is the kind for this purpose. The negative pole is connected with the foot of the bath tub by a binding screw, while the positive electrode is placed in the hands of the patient. The positive electrode is made of iron, and covered with wet wash-leather or cloth, to diminish the calorific action of the large-sized series of batteries necessary to run it. M. Pocy goes on to give a graphic description of the mode of its action. He says the current circulates through the patient from head to foot, thus traversing all the internal organs, not excepting the bones, taking along with it every particle of metal which may exist in the organism; then, by restoring the metal to its primitive form, and depositing it over the whole surface of the sides of the bath tub from the neck to the feet, but always more abundantly over against that part of the body where the metal is supposed to exist. As an instance of this, M. Pocy affirms that he once saw from a patient who complained of pain in the arm, in consequence of having taken mercury, the exact size and shape of the arm depicted or electrotyped upon the side of the bath nearest that arm, from the deposit of the metallic molecules which came out of the limb. He also affirmed that he had drawn from the femur and from the tibia of a patient a large quantity of mercury, which, according to some physicians, had actually existed in these bones for fifteen years!

But to deny that the electro-chemical bath is devoid of all effects on the human body, aside from the alleged extraction of metals, is but folly; yet at the same time there are the strongest reasons for doubting its utility or safety, as it has been thus far tested. More than one instance has come under our own observation of the injurious consequences attending this unphilosophical use of such galvanic power.

Magnets as Remedy.

"*Loadstone*" and Magnets have for centuries been supposed to have some influence on the human body, particularly in disease; but it has always been in the absence of any tangible demonstration. Professor Faraday submitted his own body to the trial, by Dr. Keil,—who, at the time, was advocating those views,—with most powerful and formidable permanent magnets, but without any appreciable result. M. Pereira states, that as early as the days of Ætius, which was in A. D. 550, it is recorded that this then marvellous "*loadstone*" was bound upon the sick part. Dr. Alfred Smee has pursued a series of experiments for investigating this matter to some satisfactory result. He placed the web of a frog's foot, and then the tail of a fish, under the field of the microscope, and there exposed them to the influence of very powerful magnets, but without producing the slightest effects upon the circulation of the blood, or upon the capillaries. He says he has also subjected the various organs of sensation to its influence, but never has been able to produce the slightest effect upon the eye, ear, nose, tongue, or skin. Nor was he more successful in his experiments on cell life, for all these trials gave negative results. From such trials, by one so competent, we may safely infer that terrestrial magnetism either has no kind of influence at all over the functions of *animal* life, or is so limited as to be usually an exception rather than a rule.

Æsthesiometer.

For the purpose of aiding in the diagnosis of certain forms of nervous diseases, Dr. Sievking constructed this little instrument, by whom it is at length described and recommended.* Its employment is based upon the principle, that the *capability of distinguishing the distance between two points*, applied exactly and simultaneously to the skin, at different parts of the body,

* British and Foreign Medico-chirurgical Review, 1858, p. 280.

varies with the tactile sensibility of the respective regions. This power, in health, always follows the general *laws of symmetry* that we find governing the body.

The absolute impairment of tactile sensibility may be ascertained by comparing a given result with the tables of Professor Weber, which are now contained in most new books on physiology. Thus, if a person in health is able to recognize, as two distinct impressions at the tips of his fingers, points of only one tenth of an inch apart, it follows, that if we find him *unable* on *one* or both hands to distinguish, say more than four tenths of an inch apart, then there must be a serious impairment of nervous susceptibility to the *reception* or *conduction* of tactile impressions.

The *nature* of the impediment must, of course, be determined by other evidences. But here it is manifest that, by applying an instrument to measure the exact tactile sensibility of different parts involved, or supposed to be involved, in a paralytic affection, we secure a more trustworthy standard, so far as it goes, to judge of the profoundness or extent and character of the affection than if we trust to the patient's description of sensations, or simply to the ruder mode of pricking or pinching the skin, as heretofore employed. There are three classes of circumstances in which the æsthesioscope, or "dividers," may be usefully employed as a help-diagnosticator: —

1. In suspected actual paralysis, to determine the amount and extent of anæsthesia.

2. As a means of diagnosis between actual paralysis of sensation, and mere "subjective anæsthesia," in which case we know the tactile powers are unaltered.

3. As a means of determining the progress of any given case while under electric treatment, or where waiting for treatment, whether for the better or not. Now, it would be superfluous to give illustrations of all these three classes of cases, showing where this might afford us some assistance. The first and the third speak for themselves, and to obviate any misunderstanding of the second, an instance is subjoined.

Case. M——, aged fifty-two, suffered, for six months before the first consultation, from numbness and *formication* about the left hand, with severe nocturnal pains along the tips of the fingers, and at their metacarpal ends. The patient rarely had pain in the thumb, and none in the palm of the hand. There was frequent vertigo. Now, to determine the character of this numbness, the æsthesioscope was tried, and the patient was found to be able to distinguish one tenth of an inch equally well at the tips of the middle and third fingers of both hands; i. e., of the sick hand as well as the well hand. The instrument therefore aided in the determination of the diagnosis, by showing that the *sensation* of numbness was purely subjective, but doubtless originating in the encephalon, as does *tinnitus aurium*, yet not the actual result of a true paralytic affection.

This instrument is essentially what is known to mechanics as a "beam compass." It consists of a square rod of brass, four inches in length, graduated and marked into inches and tenths of inches. At one end of this is a fixed point one inch long projecting at right angles, while another such point is arranged so as to slide along on the graduated beam, much like a shoemaker's measure. Certain precautions are necessary here in order to insure trustworthy results. And, first, *it is important* that the patient should not know what is expected; therefore he should not know *why* the instrument is applied; and the points should not be seen by him, so that the eye may not influence his answers to the tactile impressions. It is of all importance, moreover, to make the two points to touch the skin exactly at the same time, or there will thus be produced two successive impressions, which would alter the value of the result. We may use a pair of common dividers, or carpenter's compasses, in the same way and for the same end.

CHAPTER VI.

HYPERÆSTHESIA,—EXALTED NERVE ACTIONS AND PAINS.

"*General Principles*" *as regards the Nerves in Health and in Disease.*

Our knowledge of the *exact functions* of the different parts of the nervous system,—of nerve batteries, nerve telegraphs, ganglia stations, and other curious nerve arrangements,—we must confess, is, on the whole, scanty and imperfect. Some certainties, it is true, we positively do possess; and some strong probabilities, also, which almost amount to certainties. There is a pathological range of evidences from the brain, spinal cord, and the nerves, (omitting the great sympathetic nerve and its ramifications, for we know but little of *its* disorders,) that is fairly made out, and is well understood by some, at least; and we are at present in the right way for increasing our knowledge of this intricate subject by the greatly increased facilities for accurate research, and from the more careful collection of facts, and rigid induction of particulars, which will lead us, or those who follow us, to a safe and useful generalization. But, perhaps, adopting, as I do, the views and language of Dr. Thomas Watson, in the main, without expounding such views upon these intricate matters, it would be impossible for me to explain, as it would be for others to clearly understand, the reasoning I entertain respecting many of the manifest deviations of nerve functions, and of the diseases of the brain, spinal cord, and the nerves. We find that we are perpetually asking ourselves, when we see the ordinary healthy functions of the nerves *disordered*, Is this disorder the result of *disease* in any part of the nervous matter itself? or is it merely *sympathetic* of disease or derangement in other parts? For there are few diseases of any kind which do not, in some

degree, modify or disturb the due exercise of the offices of the brain and nerves; and it is very difficult often, and sometimes it is impossible, to determine whether, and how far, the disturbance is primary or secondary. But let us now attend to our creed: —

First. The nervous centres consist of the *cerebrum* and *cerebellum*, the *medulla oblongata*, and the *medulla spinalis*, while the *ganglia* are the centres of the great sympathetic system of nerves. The "nervous system" is thus made up of those masses of nervous matter called *nervous centres*, and of all the nerves of the organism therewith connected, "*as a means to an end*," upon which we are utterly depending in every department of our organism and being. (See pp. 222, 264.)

Second. I include the cerebral hemispheres, together with the lobes of the cerebellum, under the common term, the *brain*. So shall I speak of the medulla oblongata and the spinal marrow in the single phrase, the *spinal cord*, or as the *cranei-spinal axis*, their endowments appearing to differ more in relation and degree than in kind. The office of all their proper functions may be included in three words — *sensation*, *thought*, *motion*.

I am inclined to the belief that the gray portions of the nervous centres (which are much the more vascular) form the part in which their own peculiar powers reside, or are generated; and that their white or fibrous portions are like the white and fibrous nerves, being merely proper conductors of the nervous influence. I incline, also, to the opinion that the influence which *originates* in the *gray* nerve matter, and is transmitted by the white, is analogous, but *not identical*, with some modifications of electricity. We already know that some of the effects of this influence may be very exactly imitated, by means of galvanism, in animals very *recently* dead; that is, while there is yet a spark of vitality left to modify or coöperate with it, *but never after*.

Third. I believe that the faculties of sensation, of thought, and of the dominion of the will, — i. e., *volition*, and the power of *originating* motion, — belong to the brain; in all probability, to the cerebrum alone. The *precise* office of the cerebellum is still involved in obscurity and dispute.

Fourth. It forms a part of my views that the *motive power* resides in the spinal cord. The muscles furnish the *instruments* of power and motion. Now, there is a certain *class* of muscles which contract without our willing their contraction, and, generally, without our being conscious that they are contracting. Such are the heart, the muscular fibres of the alimentary canal, and of the bladder, &c. These are, therefore, called *involuntary* muscles. There is another and larger class of muscles, which, in health, obey the bidding of the will, and serve the purposes of grasping, locomotion, and bodily effort. These are considered and called *voluntary* muscles. Then there is still another distinct set of muscles, of which the ordinary or *habitual* action is involuntary, yet which do submit, also, to the occasional interposing control of the will. Of such are the muscles of respiration, which act while we are asleep, or otherwise unconscious; also of such are the sphincters, which regulate the entrances and outlets of the body. The *habit* of these is involuntary, but the occasional action is prompted and governed by the will. But sometimes the involuntary action rebels against the willed action, and overcomes it. The muscles contract in spite of the will. Nay, any of those muscles which ordinarily move only in obedience to volition, do, sometimes, under the influence of strong emotion or of disease, contract independently of any effort of the will, and even in opposition to, and *in defiance of*, all voluntary power.

It seems now fairly ascertained that the movements of those muscles which acknowledge the empire of the will, depend essentially upon some momentary change in the condition of the spinal cord. This change (whatever may be its nature) is capable of being effected in three several ways, —

1. By volition or emotion, originating in the brain, and this sending down a *nerve telegraph*, which travels with electric speed to the spinal cord, whence, the requisite change having been as instantly produced, the motive influence passes, with proportional rapidity, along the nerves which connect the cord with the muscles to be moved.

2. The nervous change that is productive of motion may be

wrought in the cord — whether the brain be attached to it or not — either by mechanical, chemical, or electric agencies, operating directly upon the cord itself.

3. The given change that produces motion may be wrought in the cord by an influence that is *carried to* the cord, and not from the brain, but from the extremities of nerves distributed upon the *internal* or *external surfaces* of the body. The action of this nervous circle, whereby, I say, an influence is first carried from the surfaces of the body along some nerves to the spinal cord, — whence, again, an influence is transmitted, or, rather, *reflected*, as it were, to other certain muscles along certain other nerves, — is named, by Dr. Marshall Hall, the *reflex function* of the spinal cord. The apparatus in our organism, that is subservient to this function, is named by him the "*excito-motory system;*" the nerves which carry the impression *to* the cord, are *incident*, "*sentient*," or excitor nerves; those which convey the motive impulse *from* the cord, he calls *reflex* or "*motor*" nerves.

Again, this reflex action of nerves is independent of the will; and although often attended by consciousness and sensation, yet it is often exercised when there is neither of these; it governs the orifices by which air and food are introduced and excrements are voided. The *infant* breathes and nurses by it, while the *adult* uses his will for bringing nutriment into his mouth; in both cases, however, after the food has reached a certain point, *the act of swallowing is regulated by this same nervous function.* Nevertheless, most of these muscular acts are capable of being directed, increased, or moderated by sheer voluntary *will.* The reflex power, on the other hand, extends, both in health and in disease, to the entire system of the strictly voluntary muscles. During health it is manifested only in the maintenance of what is called their *balance* or "*tone;*" i. e., their natural tension and firmness. In disease, on the contrary, we see this power act upon them sometimes with most terrific energy.

There are physiologists who have said that the cerebral matter is incompressible, in consequence of the bony dome that contains it. This I do not believe. I am not unadvised of the other grounds upon which they rest these conclusions. Not-

withstanding, a pressure of the brain there certainly is. The surface of the brain, seen through the circular opening made in the bone, is observed to pulsate — and to pulsate with a twofold motion. With every *systole* of the heart, the brain-surface protrudes a little, and it again subsides with the succeeding *diastole*. This shows that the *tension* of the *arteries*, produced by the given contractions of the ventricles of the heart, *exerts a degree of pressure* upon the contents of the cranium.

In the second place, the brain has also an *alternate* movement, corresponding with the movements of the thorax in breathings, — *rising* with every act of *expiration*, and sinking with every act of *inspiration*. This I have demonstrated. Now, during expiration, the blood escapes less freely from the head through the veins; and thus again vascular fulness is found connected with evidence of pressure on the contents of the bony dome. When we reflect that more blood may be forced through the arteries into the brain than the venous capillaries *readily transmit* and thus remove again, it is easy to conceive of *varying pressure* upon the nervous mass within the skull, which may arise from plethora, blood poison, or deficient nerve power. This may arise also, on the other hand, from a reverse state of things, i. e., *where there is too little blood*, or "poor blood," &c.; for then the venous capillaries take it away too readily, — i. e., more readily than the arteries supply it, — and there must be *insufficient pressure*, as well as *a want of brain nourishment*. In point of fact, we *know* of some changes in the circulation through the brain, which have the effect, invariably, first, of modifying, and, at length, — if they are continued, — of arresting the cerebral functions. If *no* blood, or if impoverished blood, be sent through the arteries to the brain, death, in the way of *syncope*, ensues; if *venous* blood, or blood poisoned with bile, or uric acid, circulates in those brain blood vessels, it leads to death by *coma*. But, whatever be the nature of the unknown, and, perhaps, fugitive physical conditions of the nervous centres thus capable of disturbing, or even abolishing, their functions, it is useful to keep in our minds a distinct and clear conception of the *fact, that there must be some such*

physical condition. It is plain, that excess of pressure may cause fatal coma, or defect of the usual pressure fatal syncope, and yet no evidence of the operation of the cause be left in the dead brain.

It is certain, then, that, whether the cerebral pulp yields or not, there is a constant alternation of a greater and then of a less, compressing force exerted upon it during life. It is not improbable that this continual variation of the compressing force may be *essential to the performance of the cerebral functions.* May not the brain be thus incessantly *charged*, says Dr. Watson, if indeed it be, as has been suggested by no less a philosopher than Sir John Herschell, "an electric pile constantly in action," discharging itself by the nerves at brief intervals, "when the tension of the nervo-electricity, developed, reaches a certain point"? However this may be, it is equally certain that, at times, or under certain conditions, the compressing force on the brain may greatly transgress its natural range and limits in either direction,—i. e., it may be too great or too little. The functions of the nervous centres are thus liable to be deviated, perverted, or lost, both when the pressure becomes excessive, or, on the other hand, when the brain pressure is insufficient.

In speaking of *Hyperæsthesia*, and the diagnosis of diseases of the nervous system, and more especially of the *sensory nerves*, Dr. T. Laycock says, "*Pain* is preëminently the *symptom* by which we become conscious of disease in the organism; it is, in effect, the sentinel that warns us of impending danger."

By the term hyperæsthesia, this condition of the nerves is meant, viz., an exalted susceptibility to impressions; a condition expressed by tenderness;—*pain* and tenderness are its characteristics. Not in virtue of a change in the tissues that surround the nerve fibrils, and thus involving them as in inflammation; but in virtue of a change that is limited to the nerves, in some part of their route from centre to periphery. The pain that arises from a morbid state of the *nerves* only, and the pain that arises from a morbid condition of the *tissues*, to which those nerves minister, are, therefore, expressive of two widely

different morbid states: the one is neuralgic sensibility, the other is the pain and tenderness of an inflammation. Being thus widely different in their nature, they require a widely different treatment.

The correct diagnosis of the two conditions, and a true estimate of the value of the given pain and tenderness, as leading symptoms, are of the very first importance. The seat of neuralgic *pain* is frequently in the termination twigs; but that is rarely the seat of the *cause*. It is to the trunk of the nerve, or to the sensory tract of the cerebro-spinal axis, that we must look for this. In the pain of inflammation, the cause is local; and when it is external there are tumor and rubor. The morbid condition, giving rise to hyperæsthesia, may be seated in the nerve fibril, or in the central axis; and it may be either primary or secondary. Any cause which *exalts* the sensorial function in either point, gives rise to hyperæsthesia, as a mechanical injury or contact, or congestion of the neurine. Nerves of sensation passing through *foramina* in the bones, or *winding around bones*, or *tendons*, are peculiarly liable to the first-mentioned causes. Hence the nerves of the face are so much more frequently neuralgic than others. *Spicula* of bone, or of cartilage, or analogous deposits in or on the sero-fibrous envelope of the spinal cord, are of this character. With regard to other causes of hyperæsthesia, *the most frequent*, and most important, is a propagation of irritation from the peripheral twigs to the central axis; then a diffusion of that irritation through the gray or white matter, so that it then involves other nerve fibrils, and a consequent extension of the pain and tenderness to other sensory nerves. We thus explain the pains experienced in the hips and thighs from congestion of the uterus. This transmission and diffusion of irritation *may be* from contiguity, as in the case just mentioned, or from functional connection, as between the mammæ and ovaria, or uterus; or the sympathy may arise between parts deriving their innervation from a common system of nerves, as the uterus and stomach. Hence the anatomical and physiological relations of the organs affected must enter largely into our consideration, when establishing the diagnosis between neuralgic and inflammatory pain and tenderness.

Hyperæsthesia of the vagus, or pneumogastric nerve, especially of its œsophageal and gastric branches, is, perhaps, the most common of all neuralgic affections; and this frequency ought not to create surprise, when we remember *how directly all mental operations act upon these nerves through the central axis* — how quickly poisons taken into the circulation react upon them — how intimate is the connection between the stomach and other viscera of the abdomen and pelvis — and how continually the nerves of the stomach are exposed to the application of local irritants. When we know that a puncture or wound of a sensitive nerve in the hand or finger will excite irritation in those of the whole limb: that from these it will radiate upon the nerves of the opposite limb, and, extending its influence upward and downward, will at last involve the trunk, and even the lower extremities, we may reasonably infer, that some such train of phenomena may occur after local irritation of the nerves of the stomach; and that the nerves of the heart and lungs, and the sensory twigs of the upper extremities, may become involved in the morbid condition, while with the extension of it upwards, *hypochondriasis* supervenes. Common as is this class of diseases, I know of none which demand more care to establish a correct diagnosis. The most common forms of this hyperæsthesia are gastrodynia, pleurodynia, pyrosis, globus, and the "sympathetic affections of the heart and brain," termed *palpitation*, *headache*, *hypochondriasis*, &c. In persons predisposed or liable to spasmodic asthma, the pulmonary plexus will also be involved, and nervous coughs, asthma, &c., will result. These symptoms vary almost *ad infinitum* in their combinations.

I should advise you, medical students, to cultivate the habit of looking upon the nervous system *as a whole;* all the parts of which act and react upon each other. It *may* be true that every nerve in connection with the spinal cord consists of the five distinct nerves that some writers represent, viz., *volitional*, *sensual*, *incident excitor*, *reflex motor*, and the *sympathetic;* but it certainly is *not proved.* On the other hand, if you conceive *all the nerves to be subject to the same general laws, but*

having different functions, in virtue of a difference in the apparatus on which they are distributed, and in the centres on or from which they act and react, you will, I think, arrive at results as comprehensive as the fivefold division affords, but much more comprehensible, and much more applicable to every-day practice. The physiology of the nervous system must be carefully studied if you would practise medicine and surgery successfully.

Sciatica.

Let us here examine the affections of the great *ischiatic nerve*, because they may be regarded as a *type* of local nervous diseases in general. *Sciatica*, in the first place, must be contradistinguished from simple *nervousness*, (in itself considered,) as exalted nervous function, or nervous derangement, or neuralgia, or perverted conditions, sensations, and motions. This malady takes its name from the great *sciatic* (ischiatic) nerve, which is the seat of the affection. The sciatic, which is the largest nerve of the human body outside of the brain and spinal cord, having extensive distribution of its branches, enables us to observe and study the phenomena of *nerve inflammation* and *the neuralgic condition* more definitely here than when similar affections are seated in smaller nerves. This great nerve trunk is formed, we must first observe, by the union of the terminal branches, or roots, of the lower portion of the spinal cord, (*cauda equina*,) which pass from the lumbar and sacral ganglia out of the pelvis, by the ischiatic notch, as a very large nerve cord. It then takes its course down the outer and back part of the leg to the foot. When the pain is seated in the bottom or outer edge of the foot, we know it is in the ultimate twigs of the great sciatic nerve. If the pain is chiefly in the *inner* and *anterior side* of the leg, or about the inner ankle, then we know it is rather in the ultimate ramifications of the *crural* (femoral) nerve. (See p. 477, and Notes in Appendix.)

Sciatica, (not sciatic neuralgia,) in its true and less frequent forms, is a real inflammatory disease, (*neuritis*,) generally seated in the nerve, or, rather, *in and about the sheath of that portion*

of this nerve, where it passes behind the neck of the thigh-bone after it has emerged from the pelvis. This is explained, perhaps, from the fact that at this spot the greater sciatic is more exposed than any other large nerve trunk in the human body. It is here liable to be exposed to severe or prolonged pressure in sitting and walking; to bruising and concussion; to irritation, as from severe toil, riding and walking; to chill and congestion, from cold, wet, or damp, or from sitting upon any cold seat, particularly after great heat or fatigue; any of which is sufficient to set up a morbid action that may amount to a *neuralgia*, a *rheumatism*, or an acute attack of *sciatic* inflammation. Now, some always regard this malady as a neuralgic or rheumatic affection; and no doubt it does occasionally partake of the one or the other specific character, because of the existence of one or the other in the system at the same time. But sciatic neuralgia may appear occasionally as a mere *symptom* of some morbid irritation in the alimentary canal, or of some one of the inter-pelvic viscera, thus being only a reflex nervous action; then, after the cause is removed, the painful condition of the nerve appears to continue chronic, just as palsy of the limbs continues, after the lesion in the brain, that was the first cause of it, has been healed.

It is all important to be able to distinguish the *organic* from the *symptomatic* sciatica. In tracing the cause of each particular case, the *history* of it becomes an important *witness*, not to be slightly questioned, because of the more prominent symptoms in all cases being so similar. Nevertheless, by careful analysis of the local and of the general symptoms, and by tracing the history of the precedent circumstances that are connected with the appearance of the pain, we shall find the apparent difficulties of the diagnosis to vanish as this investigation proceeds.

The very first symptom, mark, of *acute sciatica* — which, indeed, is manifested very soon after the exposure of the patient — is a sense of weight of that leg, together with a feeling of coldness, numbness, or a want of sensibility; and this is accompanied, or perhaps *soon followed*, by rigors, and other very dis-

agreeable general sensations, such as occur on ordinary febrile attacks. A restless, feverish, and uncomfortable night follows, after which the patient experiences a very threatening and tiresome pain in the course of the great sciatic nerve. The limb is now all but powerless, with growing pains either down the back of the thigh, (which is becoming, also, extremely tender to the touch,) or on the outside of the knee, or the calf of the leg, or near the external ankle bone, or, perhaps, involving the whole limb. If, now, the limb is moved, the pain increases, darting up into the loins, and down the limb. The patient wishes to lie on his back, with the limb extended, and complains now of the prickling sensation called "pins and needles." The attack may be more or less gradual, and the febrile phenomenon more or less great; but in any case where this affection has attained a degree of severity that characterizes the acute, the symptoms are so characteristic that no practitioner of ordinary intelligence can fail at once to recognize its true nature. But the great majority of cases that call on medical men for treatment are the sub-acute. The history and symptoms of these are the same as the acute, only less in degree and extent, and the invasion is more tame. The suffering and the lameness even here are great, and the patient finds no easy position.

In case the early stages of the acute or the sub-acute attack are not submitted to active and controlling treatment, the case is very likely to merge into the chronic form, and, as such, it may continue to harass the sufferer for any length of time. But it may be asked, Where is the line to be drawn to distinguish the acute and sub-acute from the *chronic sciatica?* The chronic disease of a nerve, says Dr. Rood, of England, differs not essentially from a similar morbid condition of other structures. The term "chronic," when applied to disease, does not indicate merely or exclusively the idea of duration, or long continuance, as the origin of the word — *chronos*, time — would seem to imply, but, rather, *designates a special form of morbid action.* Then, observe, the symptoms of pain, tenderness, weakness, &c., will be present both in the sub-acute and in the chronic. In the former they will be intensified by exercise; in the latter, at

first, diminished thereby — i. e., within certain limits. In the former, the sufferer will commence his walk feeling but little pain; but at every step it increases, and the farther he walks, the more severe it becomes. In the chronic sciatica, he feels stiff, and starts with difficulty; but, once up and off, he progresses with more and more ease after having walked a little distance, and then may even feel almost well, for a short time, being quite free from pain: but if he extends his rambles, a feeling of fatigue soon creeps on, followed by pain, and these increase. The exercise thus acting as a remedial agent *to a certain extent*, that limit passed, it becomes an irritant, and then tends, on the contrary, to aggravate the very disease upon which it had just before exercised a beneficial effect. Now, a delicate illustration of this is observed in treating an ordinary case of inflammation of the conjunctiva of the eye, which, moreover, shows the striking effects of the judicious and *skilful* use of different stimulants in the varied treatments of disease. At the very turning-point of a case of this kind, the application of an appropriate stimulant operates upon the disease "like a charm," and, for the patient, most advantageously. If the application be *delayed*, a stimulant of the same strength would prove useless, or worse than useless; to produce the desired effect, its potency would then, probably, need to be doubled. But, on the other hand, where the stimulant is applied *too soon*, — i. e., prematurely, — or if too strong, it operates then as an irritant, and rather augments the disease it was intended to cure. Exactly similar effects are produced upon the *nerves*, although hidden from view; for it is a law in therapeutics that, whether the application be direct or indirect, stimulating or soothing, the same influences may be brought to bear, and the same results obtained, upon diseased parts, wherever seated.

It is obvious that an *inflammatory* action cannot go on long, in any structure, without producing important changes in its organization. The more active the disease, and the more delicate the tissue, the more rapidly will a healthy structure be deteriorated, and the function of the organ be deranged. But probably *the sheath of the nerve* is the primary seat of the dis-

ease in true sciatica, which becomes greatly thickened, first, by venous congestion, and, secondly, by fibrinous deposits. This thickening of the surrounding tissue causes a pressure on the fibrils of the great sciatic cord ; and any lurking inflammation in the sheath of the nerve must, after a time, extend also to the medullary matter contained within it ; and this may explain the coëxistence of the two opposite sensations of numbness and of pain. The latter is supposed to result from the morbidly increased sensibility of the membranous structure which usually attends inflammation ; the former, from the compression of the nerve substance itself, caused by the thickened sheath.

Dr. Marshall Hall gave a graphic account of a severe case of sciatica, but a short time before his decease, which illustrates how this great nerve may be thus utterly disorganized, and its functions at first perverted, and finally destroyed. The whole limb, in that case, became useless, and wasted away, ultimately, to mere skin and bone. But this result is only occasional. In the worst cases, although lameness may persist for a long time, yet usually the sufferer ultimately regains mostly the use of the limb.

No form of electricity is found useful for acute inflammatory sciatica, unless it be actively employed within the first twelve hours after the sensation of weight, coldness, and numbness in the limb, and while the rigors and the horripilations are still inaugurating the attack. And if this does not peremptorily cut short the invasion, as it usually will do, particularly if it has been aided with ten or twenty grains of Dover's powder, thorough warm bath, and careful nursing, then the acute sciatica must be surrendered to *an active antiphlogistic treatment* by smart aperients, bleeding or leeching, antimonials, or other diaphoretics, as best adapted to the individual constitution and habits, which then must make the first chapter or " act " in the work. The next must be tonics and ferruginous preparations, if the patient is feeble or aged ; but if in the prime of life and good general health, then quinine, or Fowler's solution, or mineral acids, are indicated. If plethoric and vigorous, let a small bottle of congress water be taken every morning for a week, and

repeated every alternate week. Rashness and timidity are equally to be avoided in the treatment of nervous diseases. One may push his antiphlogistic treatment so far in some slight case as to debilitate his patient unnecessarily, while in another case the same treatment would not have been severe enough to conquer. Another may err in adopting only palliatives, or mere soothing and temporary relief, where the case, on the contrary, demanded most active and prompt treatment to insure a cure. Therefore, whether the case be acute or chronic, the skill of the practitioner will be shown by the correctness of his opinion as to the seat, the nature, and intensity of the affection, and by the precision and judgment with which he selects and applies the remedial agents at his command — doing neither too little nor too much, but doing right, *and at the right time.* If he strikes a vigorous blow, he does it with just sufficient force — enough and no more — to produce the effect intended; and then he fails not to follow up the advantage gained by calling to his aid such other appliances as are found to have power to complete the restoration. These are our *general principles*, and are intended to apply as well in the treatment of any other nervous disease as for *sciatica.*

To this end we see the importance of a more intimate acquaintance with electro-physiology and electro-pathology, and with the peculiar symptoms and treatment of the nerves, for dealing faithfully and satisfactorily with these diseases, either in their idiopathic or traumatic derangement. This will form the second chapter or "act" in the work of treating the grand malady of sciatica, as well as all other nerve affections.

Now we come to the third and last "act," which alone is the work and special province of *electro-therapeutics.* Here let me forestall the older and erroneous notions of "*temporary relief*" by electricity. Dr. Rood recently said in his excellent dissertation on the subject, that sciatica "is, *as a general rule, and almost without exception, neither a gouty nor a rheumatic affection;* and I am fully persuaded," he says, "after carefully studying the subject, and watching the course and character of the malady in all its forms, that those who hope to *cure* it by a special medica-

tion, on the ground of supposing it either gouty or rheumatic, will necssarily fail in the attempt. They may keep their patient under treatment, trying this or that medicine for many months, the malady meantime fluctuating, but showing no signs of *yielding;* if recovery does take place, it will probably be at some remote date, and that perhaps after several years; the sufferer apparently being in no degree indebted for his recovery to the aid offered by the medical treatment, or liniment appliances. Such cases reflect no credit upon the healing art; yet the fault lies not so much in the art itself, as in the person who professes to apply its resources."

A patient is laboring under supposed sciatica; now, if it is truly so, whether neuralgic or inflammatory, you will find that if you press firmly near the posterior edge of the trochanter major, or near the superior spinous process of the ilium, or at the upper part of the ischiatic notch, in all probability not only will the point so pressed exhibit tenderness, and perhaps pain, but the patient will tell you that a distinct pain also shoots down the limb, and request you not to repeat it. These are the more usual results of such investigations in sciatic affections.

There is, moreover, a kind of sciatica that now and then presents, which, if not correctly understood, will be difficult to cure; for it is truly associated with *disease of the roots of the anterior crural nerve*, the more prominent symptoms of pain and impaired muscular action manifesting themselves mostly in parts to which the branches of this nerve are distributed, and at the same time the great sciatic nerve appearing to be exempt from disease, i. e., *at first*, but some time *afterwards* (mark this) giving evidence of some trouble there, particularly after any considerable or unusual amount of exercise. But when it is remembered that both the *anterior crural nerve* and the *great sciatic nerve* receive their originating branches for their structure from the same *fourth pair* of lumbar nerves, and are, indeed, but the prolongation of the sacral ganglia, it is seen that there is a very close relation between these two great anterior and posterior nerves of the lower limb. The roots of these great nerves therefore perforate the psoas muscle, and this may

account for the increase of the severity of the symptoms after walking in such cases. We may conclude that where there is *absence* of tenderness over the exit and course of the trunks of these two great nerves, and yet evident sciatica, then in all probability the seat of the disease is rather at, or near, the deep-seated *roots* of the nerves, and that the psoas muscle, as in walking, is probably the irritating agent. A large blister applied at once over the whole lumbar region in such a case, and repeated a few times, will materially aid in *preparing* for the cure. The compound iodine ointment, or tr. iodine fortis, may be substituted. But the repeated application of *direct* Galvanic or Faradaic currents will be found the most effectual means for completely clearing those deep-seated nerve roots of any remaining venous congestion, or discrasia, by catalysis.

Cases of *symptomatic* sciatica are not rare. This form of the disease arises from retained *scybala*. Having observed that in all these cases *the right leg* is the one affected, we believe that the indurated *fæces* or *scybala* are impacted in the *cæcum* and ascending colon. Dr. Hancock was the first to give this explanation of these cases. These may be *acute* and severe cases, simulating the acute form of sciatica, or they may be *chronic* and simulating the rheumatic or the true chronic sciatica. Remove the cause, then, first *by active purgatives*, as turpentine and oil, or croton oil, or colocynth pill; and then arrives the time to apply the electric current to the loins and bowels, without delay, so as to give tone where was atony. *A constipated habit must ever after be sedulously avoided, even for a day, by every such patient.* Aperient medicines are, indeed, most efficient *assistant* remedial agents in the treatment of this as well as some other forms of sciatica.

Finally, we may be satisfied that the much known and little understood *sciatica* occurs as an *acute* disease, whose inflammatory character requires an active antiphlogistic treatment. *Sciatica*, moreover, occurs as a true *chronic* disease, where blisters, iodine, and electric currents are required to eradicate it; *sciatica* may occur as a *symptomatic* disease, and that either acute or chronic, which requires active aperient medicines, together

with electric currents, to restore tone and function; *sciatica* may occur with a *rheumatic taint*, or any two or more of the foregoing forms may occur in the same case; but, after all, *it more generally occurs as a pure neuralgia*, and simply requires good electrical treatment to cure it. (See p. 475.)

Rheumatism.

Dr. Gordon, of this city, says he treats an attack of acute rheumatism in the following manner: "After having procured free evacuations by means of senna and salts, I begin the administration of equal parts of vin colchici and spirits terebinth, in ten-drop doses, every two or three hours. Then, after a day or two, I give, in connection with the just-named prescription, (but only at longer intervals, say of six hours each,) tinct. ferri chlor., ten drops, using as much opium as necessary to quiet pain. I also allow a free use of good coffee, that is of average strength. If the appetite remains, the patient is allowed a moderate use of his usual food, at the usual meal time."

The author has found the above admirably adapted to some cases, while in others, — i. e., for abbreviating the discouraging *duration* of acute articular or periosteal rheumatisms, — the administration of large doses of iodide of potassium, with a sufficient quantity of sulphate of morphia to control the outrageous pain, proves to be the better means. Give, in the course of the day, from ten grains to half a drachm of the iodide, with, say one half, to one and a half grain of morphia. Bathe the joints and painful parts in a lotion of the cyanuret of potassium, or soap liniment with opium or New England rum, then cover with water dressing, and all well covered with dry flannels.

Disease of Articular Cartilages. — Upon inquiring into the *pathology of diseased joints*, Dr. Bryant, assistant surgeon at Guy's Hospital, says, articular *cartilages* are so related to two anatomical divisions of tissues, the hard and soft, that they offer an unusually good opportunity of examining the process of cell development, and afford equally to the pathologist the means of studying the changes which *nucleated cells* undergo in their degeneration or decay.

Now, the difference between what is called vascular and non-vascular tissues (to which latter division articular cartilages belong) is known to be so slight, that the method by which this structure is nourished is no longer doubtful. The blood being conducted to every tissue by its ordinary vessels, each tissue extracts, or rather *imbibes*, the material requisite for *its* own best nourishment; the only difference between the vascular and non-vascular parts being determined by the space through which this process of imbibition takes place; in the latter, the vessels do not perforate its substance. The nucleated cells, however, through which all the living structures are formed, and grow, still do absorb from the vessels, however distant, their quantum of nourishment; and in articular cartilages, these cells are as active as in any other tissues.

The method by which these blood vessels supply the articular cartilages may be thus briefly described, the necessity to understand their vascular supply being evident when their pathology is looked into. That the principal source of supply is derived through their bony attachment, the researches of Birkett, Toynbee, and others have full well demonstrated. The vessels at their bony base form loops, and yield the required nourishment "somewhat in the same way as the epidermis scales are nourished upon the vascular loops of the corium." The vessels ramifying into the synovial membrane furnish, at their circumference, to their adjacent surfaces the sufficient supply.

It is clear, then, that structures deriving their nourishment through other adjacent tissues must depend much upon the *integrity* of these tissues; and here such an example is witnessed, particularly in old people. Articular cartilages are liable to diseases which may all be classed as the enlarged or *hypertrophied*, or *atrophied*, that is, wasted. They are peculiarly liable to granular, fatty, and fibrous degeneration, but not to inflammation. Now, all these seem to arise either from perversion of nutrition, or else diminished or arrested nutrition, but never through excessive vascular supply, or through single excess of function. Hence the reasonableness of electric currents, properly applied, being of the greatest service, in all such joint affec-

tions, *when not complicated* with inflammation or ulceration of the adjacent tissues.

There is a kind of *chronic rheumatism* which we not unfrequently meet with, that shows its peculiar character by deposits in the cutis, in the sub-cutaneous cellular tissue, and also in the cellular tissue of the muscles. These considerable effusions very speedily become hard callosities, and are not only felt but *seen*, situated in isolated spots, or else are numerous in a given space, or conglomerated so as to cover a larger extent, and so near the skin, or actually involving the under structure of it, that a fold of the skin cannot be pinched up over such spots. These are attended with harassing pains, and even loss of power, to helplessness; while other cases suffer little from them. But if early treated by localized electric currents, these lumps can be solved away, without being scattered to any other part. A brisk current, directed through the spots, is required, and that continued for a longer time at once on each callous spot, than we are in the habit of using the current for any other purpose.

Rheumatism does *not* appertain to cell life, as its characteristics of pain, shifting of seat of swelling and of the pain, formation of lithates and its deposits, do certainly indicate. Rheumatisms which are more frequently presented for electrical treatment are of the *chronic forms*. In all reason and fairness, too much is expected of electro-therapeutics in most affections for which they are resorted to; and particularly is this true in those cases where there is a rheumatic *taint*, discrasia, or diathesis, for this special condition or bias of the organism is always giving occasion for fresh attacks. Notwithstanding, we are prepared to show the preëminent power of electricity in pure forms of rheumatism of every sort, excepting only the actively acute. The acute form of rheumatism comes on with fever, or perhaps even before the appearance of febrile symptoms, with excruciating pain in the larger joints, which are also swollen and more or less red. This may shift to another joint, — the whole lasting some six weeks. One of the essential symptoms of *acute* rheumatism is, that the skin is daily or nightly bathed in a profuse perspiration, and yet is hot, nor is the pulse or the pain in the

least relieved by it. This form of the affection will usually run its course in spite of treatment, although the medical attendant can influence it to run a milder and a more bearable course, and usually guard against the *liability* to metastasis, i. e., translation or extension of it to some internal part, especially to the heart. But the acute form of rheumatism rarely terminates in the chronic form. The person that is subject to the one kind seldom is found to have the other, and *vice versa*. But the occurrence of either kind leaves a liability to its recurrence on very slight exposure or error of diet or habit, or even from a change of wind or weather, i. e., change in the atmospheric electricity.

Chronic rheumatism of almost every sort, whether capsular and seated in the lining membrane of the joints and bursæ of the tendons, or when it attacks the feet or the hands, the hips or shoulders, the knees or elbows, the muscles, fascia, or periosteum of the skull, vertebræ, or shafts of bones, — all, all of them are wonderfully amenable to the catalytical power of Galvanism, or the disturbing force of Faradaism. It is known that the pain of these chronic forms is sometimes confined to one or several joints; and at another time, it shifts from one part to another, and that without being attended with inflammation or fever. The patient is very liable to become lame, or even crippled by contractions and pseudo-anchylosis, and liable moreover to frequent painful recurrences. The effusion of coagulable lymph, after each fresh attack, tends to a permanent thickening of the parts. Now, unless these deposits have existed very long, or have far degenerated into old cartilaginous, callous, or chalk and tendon nodosities, so as to greatly resist the in-working of the current, electricity, and particularly that form of it we designate as primary or galvanic, and even electro-magnetic currents often, can solve out and remove these deposits of effusion, wherever their seat may be, *if recent*.

Rheumatalgia, then, even where it resists all other treatments, can often be reached and nearly eradicated by the correct and thorough use of electric currents, at least for that time, so as no other remedial power can do it. If a rheumatism is thus treated and broken up at every new attack, for a few times, if the

urine testifies that the kidneys are at fault, and they can be corrected, also the diet and habits are corrected, the assimilation and disassimilation all rendered efficient in their respective offices, and the patient wears flannel and woollen clothing, *the rheumatism is cured.*

The more speedy and *effectual* throwing off a fresh attack of rheumatism, whether in the bones or muscles, is very greatly facilitated by baths of soft warm water and a plenty of soap. The water should be quite *blood warm*, but never over 95° Fahrenheit. The air of the bathing room should invariably be warmer than the water of the bath, and the patient should exist day and night in a very uniform temperature.

Dr. Fuller, of St. George's Hospital, in his work on Rheumatism, Rheumatic Gout, and Sciatica, page 456, says, if the sciatic nerve is the part implicated in the real rheumatismal pain, he orders the whole affected limb to be encased in flannel that is thickly sprinkled with sulphur. This flannel is kept in place by means of a bandage, and the whole limb thus bandaged is covered with oiled silk, or rubber cloth, which has the effect not only to increase the warmth of the limb and confine the vapor of the sulphur, but it also obviates the disagreeable odor. The bandage and flannel should be kept on day and night.

Here, doubtless, is an old *galvanic* remedy, which Dr. O'Conner has brought up anew as valuable in given cases of rheumatism. To be effective, so that good results may follow the external use of sulphur, the flannel and bandaging should not be removed until after several days — say three or four at least. Where the case is attended with *feverishness* and with very acute pain, experienced even when the limb is at rest, no relief results from its use; nor is there any good from it when the skin is dry and inactive, for, in such cases, the sulphur remains unabsorbed and without curative action. But, he says, where there are no symptoms of active disease, when the pain is of a *dull*, *aching* character, and is felt chiefly, if not solely, when the limb is in motion, — and more especially when the skin acts freely, and the sulphur is absorbed rapidly, so as to require renewing every third or fourth day, — then nothing is more ser-

viceable than the *sulphur bandage*. In these cold and old cases of rheumatism, the sulphur may be taken internally, with some tincture of guaiac, or the citrate of ferri and quinine, and, at the same time, actively apply electric currents, according to the rules for the rheumatic cases, and the recovery will be greatly expedited, and the cure (?) will be more likely to be lasting.

There is a kind of *face-ache* which, as Dr. Watson says, cannot be recorded, properly, as a species of neuralgia; for it does not occur in short, stabbing paroxysms, nor is the pain acute enough to entitle it to the name of *tic douloureux*, but which is, notwithstanding, very common and distressing, and, under ordinary treatment, is often very intractable. This is called, by some, a rheumatic face pain. It occupies the lower part of the face — the jaw especially; but the patient cannot tell you exactly whereabouts it is most intense. It is often thought to proceed from toothache; but perhaps the teeth are all sound, or suspected teeth are extracted with no relief. This pain is doubtless *periosteal* rheumatism, and proceeds from a cold; or it may sometimes be a muscular hyperæsthesia, or even partaking of both of these. If not inflammatory, we are to apply electric currents as for neuralgia, and give the patient iodide of potassium in five-grain doses, which will speedily work a cure. When this does not succeed, which is very seldom, then the muriate of ammonia, in half-drachm doses, well diluted, and given every six hours, will soon eradicate the malady. (See D.)

It is well to bear in mind the opinion that M. Ricord, of Paris, has arrived at from his extensive experience; and that is, that the iodide of potassium makes an impression on the cerebro-spinal nervous system that is sometimes made perceptible in cerebral excitement proceeding from congestion, and with symptoms like those of ordinary intoxication. At other times the motor nerves are slightly affected, giving rise to *subsultus tendinum* in a slight degree; and it is said that amaurosis has, on rare occasions, (from over-dosing,) supervened. This is a powerful *galvanic* remedy, and requires to be prudently administered.

Dr. J. C. Christophers gives the following results of the use of electricity in chronic rheumatism.* The first case, he says, was one of three years' duration, and of most intractable character, — the patient having undergone long courses of active medical treatment, besides sea-bathing, and then homœopathic treatment. "At first," he says, "I passed a current down the spine *for half an hour*, or longer; then from the spine to the hand *for an hour*. At the end of a few weeks, she began to experience a feeling of warmth in the hands, and their strength gradually returned, so that by degrees she resumed her labors in her laundry, continuing the galvanism daily, as before. Her hands have now almost, if not quite, acquired their former power, (the distortion of course remains,) though she is still under treatment for the feeble condition of her ankles and knees, and is galvanized three times a week, with increasing benefit to both. Last winter this patient was confined entirely to her bed; this winter she has not kept her bed a day; moreover, she has regularly followed her occupation through a very severe season, and surrounded by circumstances eminently tending to produce an accession of her disease.

"Case 2d. — A fine, well-made man, in the prime of life, was attacked, some years since, with severe pain about the 'hip-joint,' extending to the knee, which was at first treated as rheumatic, by drugs, counter-irritants, &c., and by the introduction of needles at short intervals from the hip down to the knee. No benefit was thence derived, and he was obliged to throw up his employment. He consulted several practitioners without obtaining relief, and amongst others myself. He complained of great pain in the buttock and in the knee-joint. The affected limb was two inches shorter than the other, much less in circumference, flabby, and cold; the power of motion was perfect, though sensation was evidently impaired. Here was another intractable case, in which a host of remedies had been tried without success; still there were circumstances about it that induced me to add electro-galvanism to the number, and with

* Braithewaite's Retrospect, No. 17, p. 288.

these results: that the pain gradually decreased, and the limb regained its size, strength, firmness, and temperature, and that the patient is now able to earn his living by following his occupation. The shortening of the limb of course remains.

"Case 3d is an abstract of an account by the patient himself. In July, 1833, he was attacked with fever, from which he recovered in a week or two, but found his left foot numbed, and that he walked lame. This increased; then came a difficulty in retaining his urine. In this state he became a patient in St. Bartholomew's Hospital. Liniment was applied to the foot, and four moxas to the loins, followed by poultices, and warm baths three times a week. After three weeks, he left the hospital unrelieved; but the urinary symptoms remained troublesome, and weakness increasing, he became an out-patient at St. George's Hospital, where he was several times cupped, often blistered, &c. The patient reports that he remained in the same state till 1859, when he was seized with pain in the back, which was relieved in a week or ten days. Severe pain then attacked the foot in which he first experienced the numbness; and two months later the other foot, with the leg and thigh, became painful, and he was for three weeks in continual agony, the urinary annoyance continuing very troublesome, and the pains occurring occasionally, sometimes in one leg, sometimes in the other, occasionally in both, but never extending beyond the middle of the thigh. He found great difficulty in walking, which appeared to have increased during the previous year.

"Such was the state of this patient when I saw him. There was little doubt he was suffering from organic disease in the spinal cord, and I had no difficulty in tracing its origin to a severe injury done to the back, by a fall from a horse, some years since. Then came the question, was this a case likely to be benefited by galvanism? I thought not; but this patient was the friend of the subject of case second, and was most anxious it should be tried. I consented, and the result was as follows: The incontinence of the urine gradually subsided, though it never entirely ceased; the legs acquired strength; the gait became firmer and less tottering; and the foot acquired warmth.

Such was the state of matters after three months' treatment by galvanism! What further improvement might have been attained, (cure, of course, was always out of the question,) had the means been pursued, must be conjectural, for at this period the patient became weary of the treatment, and ceased to attend. That any amelioration should be attainable in so bad a case, must speak well of the means that procured it. Though I do not hold it up as one of success, *I do hold it to be successful in some degree*, inasmuch as galvanism doubtless did more to relieve than any of the other remedies employed."

Case. — Everett G. presented at my rooms for electric treatment with old rheumatic contractions of the flexor muscles of the right forearm. This was an extremely bad case of general rheumatism, which appeared to affect him in all his extremities, showing swellings or enlargements in both his hands and feet; but the greatest suffering was about the right shoulder joint, and so down the arm.

Treatment. — At first, gave him a sitting with a current from twenty Daniell's elements, through and through the shoulder from front, backwards, by placing the *positive* electrode over the upper portion of the pectoral muscles, while the *negative* was over the nerve *circumflexor humeri*, and this was maintained for two minutes. I then moved the negative a little to the posterior lower portion of the muscle *deltoides*, for two minutes more; next from there to the nerve circumflex for two minutes; next from there to the *fossa supra spinata*, with an *up-running* current; this finished the *seance*. Next day found him greatly benefited, not only in that arm, but every other way; repeated such applications for ten days, when the contractions of the arm were quite gone. The next few days directed the current *upwards* through the extensor muscle *triceps*, and *downwards* through the flexor muscle *biceps*. Progress now very great; can lift his hand to the top of his head, which he has not been able to do before for ten or twelve years. He was encouraged to continue to come once or twice a week, and the after-sittings were devoted, respectively, first to this joint or limb, and then to that, until he was almost as supple and well as ever.

Case. — Joseph M., of Cambridge, nineteen years of age, had uniformly good health, but mother is very rheumatic; was attacked with *wry neck*, one day after skating, some two months ago; head turned to right side and firmly fixed by the apparently double process, viz., paralysis of the left *sterno-cleido-mastoideus* muscle, and the clavicular portion of the *trapezius* on the one side, while there is a firm tonic contraction of the antagonizing muscles on the other; and these were as hard as wood, and utterly disabled him from holding up, rotating, or swinging his head in the least. The contracted muscles are painful to pressure, and are evidently ready to pass into a state of atrophy and degeneration.

Treatment. — I first placed a large moist sponge electrode, which was the *positive*, near the base of the skull on the contracted side, with the *negative* electrode slid along, from half minute to half minute, from one to the other, on the lower portions of all the contracted muscles, with a current from twenty Daniell's elements, until their polarity was fairly modified; and then the electrodes were removed to the opposite side and placed *reversed* on the relaxed and palsied muscles, employing a stronger *up-running*, *prevailing* current, but taking care to produce strong and rapidly succeeding contractions in those muscles, both by suddenly breaking the current, and by reversing the current by the *current-changer*. In five sittings this patient was perfectly cured. (See p. 475, and Notes in Appendix.)

Case. — M., a young lady, twenty-four years of age, presented for electric treatments; had suffered from long stages of ill health, and even from infancy had had throat affections again and again, as sore throat, inflamed and ulcerated tonsils, enlargement of tonsils, inflammation of salivary glands, catarrh, and, at the same time, there were painful swellings of some of the flexor muscles of the arms, which had been repeatedly treated by Faradaic currents. I undertook the case, and first applied the primary current of galvanism daily for one month, mainly by embracing between the electrodes the enlarged and hardened glands about the throat. The effect was truly surprising, for after a few days, some large masses about the neck would actually shrink and disappear while under the current and strong

pressure of the electrodes, at a single *seance*. In the subsequent sittings the current was often run from the brachial plexus to the tender and contracted muscles of the arm and forearm, and then *up the extensors* of the hands and arms, which were wasted and greatly enfeebled. In eight weeks from the commencement of these treatments the hitherto helpless, distorted, and painful fingers and hands could be opened and shut, and the arms could be well extended, but not much rotated; however, she was enabled to undertake light hand work. It is now ten months since she was dismissed, and her still further improvement in general health, in the appearance of her neck and throat, and in the use of her hands, is quite as astonishing as her early and speedy improvement while under this treatment, after having resisted all other means for a lifetime.

Case of Mr. William Wood, repairer of wet cellars, builder of drains, was often and long exposed to wet; has been subject to rheumatism whenever he is in the water and mud for any length of time; was formerly inclined to perspire very freely upon exercise, but now whole body and limbs are dry and show "*goose-flesh;*" is very chilly upon first removing his clothing; both feet swell greatly, with more or less swelling as far up as to the knee; this swelling goes and comes pretty regularly every three or four days, with more or less pain and stiffness, twitchings in the muscles of the lower limbs at night, particularly soon after lying down to sleep; occasionally extremely severe pains in hips, one or both, but no pain there just now. On the whole, is weaker on the right side than on the left, in the arm as well as leg; protrudes the tongue with great trembling; tongue deeply indented on its edges with the teeth; eyes twitch, and there is a general stiffness and insecurity of movement of the whole body, which has increased greatly in the last few months; momentary twitchings of the muscles in the different parts of the body and limbs: the evidence of peculiar debility was every where very marked.

With this view of the case he was treated by primary currents, using at first from twenty to thirty Daniell's elements, and placing the positive electrode over the second lumbar space

while the negative was pressed, for one minute, deeply into the glutei over the great ischiatic nerve trunk; then, removing the positive to a place over the femoral nerve trunk, under Poupert's ligament, while the negative was removed to the inner ankle, and the current let on as before. The *cauda equina* appeared to be the very seat of the difficulty, notwithstanding a dull pain in the head and a somewhat hemiplegic appearance of the disease; therefore the negative pole was mainly planted there for *circle* treatments, also when directing the current down either limb. He was advised to keep dry and warm, and this method of application of electricity to be kept up regularly every day. In three weeks' time he appeared, and said he felt, like a new man; the trembling of muscles entirely gone, the pains were scarce and far between; he was able to walk and move about with considerable freedom and ease to himself — to continue the electric *seance* every day for ten days more. This man completely recovered, and is now well for doing business, and possesses remarkable powers of endurance.

The *cauda equina*, it must be noted also, is a most frequent seat of protracted neuralgia, without necessarily involving either the spinal cord or its theca in any change of structure. The evidences of such neuralgia are aching or burning pains in the loins; stooping gait; tremblings in the muscles of the loins and thighs, particularly after fatigue, when there is also experienced great weakness there, but not actual paralysis. Now, in all these cases, the *circle treatment* will best wash away *the pain-causing condition*, whether we employ the galvanic or the electro-magnetic currents. (See F, in Appendix.)

Dolor spinalis, or that pain which occurs in the back, particularly in the spinous processes of the vertebræ, and which is so characteristically *augmented by pressure*, and therefore put down always as "*spinal disease*," is not, by any means, always truly so; for I find, among these cases, a large majority of instances of simple and true rheumatic periostites, in varying stages and degrees, from the dull ache and lameness of chronic rheumatism, to the very acuteness and twingings of neuralgia, and sometimes even equalling the burning and throb-

bing sensation which characterizes inflammation of the periosteal coverings of the spines and bodies of the vertebræ, only it comes on in very distinct rheumatic-like attacks, whereas in inflammation it is more persistent. *Circle treatments*, with Faradaic currents, will cure this; and then the internal administration of the iodide of potassium, together with restricted labor and habits, can fortify the system against the culminating of this pain-inducing condition. (See pp. 408, 430, 475, and C.)

Rule. — In those cases where there are "*contracted muscles*," and if these, for example, are mostly about the shoulder, then we are to apply one electrode on the arm below, with a one-way *down-running* current of primary and constant galvanism; since, from all past experience, this proves the best means for permanently relaxing them; but in those cases where the muscle contractions are farther down on the arm, or in the hand, then the *up-running* current will the better succeed, provided the direction of the current in either case is never reversed on the same muscles for flexion, at the same *seance*. Yet a constant *down-running* current, led, for example, from the pectoralis to the palm of the hand for one minute, may be succeeded by an *up-running electro-magnetic* current *on the extensors* of that same limb for *half* a minute, and thus alternated for two or three or half a dozen times with extra good effect; indeed, thus succeeding where either may have failed before.

When muscle rheumatism has its seat either in the muscle fibres or in the fascia just under the skin nerves, it may be known by the flying pains, and the extreme change from place to place; and this characteristic is still more marked while the electrodes are being applied. Here then the quick touches and lively-gliding movements of large and soft electrodes and smart currents are very often sufficient to chase away at once all these pains. The best way is to attack these pains boldly, holding and *moving* the electrodes all the while with but a few inches between them, allowing no painful or tender spot to go untouched, until all pain is eradicated, and so that the contracting of the muscles or any motion of the body or limb

cannot reproduce it. I find that *labile contractions* of the muscle fibres are really required to exterminate *this condition* for pain, as also to loosen the stiffness of the joints below where the tendons of the muscles are inserted. Such persons must be advised to *avoid a damp air*, either as a place of business, or lodging or residence, and to wear their flannels in summer, and thick flannel in winter, until a painless *habit* and *endurance* of the nervous system of that person become established.

Gout.

In *atonic gout*, or that condition which we find after the fever and inflammation of an attack have subsided, not only in regular inflammatory gout, but also in those masked cases of wandering or *radiating* gouty pains, electricity, when correctly applied, is of untold value, for it not only relieves, but it breaks up, *the pain-causing condition*, whatever that may be ; so is this true of it in *gouty*, as well as rheumatic, *nodosities*, and in the wandering or flying pains of rheumatic gout. Moreover, we often find, during the stages of *arthritis nodosa*, that the epiphysis of phosphates or bony deposit and pseudo nodosities recede, after a time, particularly if about the shoulder joint, leaving an extremely sick and weak state of the neighboring muscles of the shoulder and arm, which, if not promptly treated, soon become soft and lean, the flexors taking on a condition of tonic contraction and hardness, while the extensors yield to the perpetual traction, and assume a state of partial wasting paralysis. Now, by a skilful use of electricity, this evil may be averted, and even a more or less restoration may be obtained where it already exists. (p. 476.)

The treatment of such cases may be successfully conducted by means of either primary or secondary currents; but here I have found that the alternate use, first of electro-magnetism, and then galvanism, at each *seance*, or, rather, the first few days the former, and then the latter for a few times, to give the best results. The induced current must be employed with the least possible catalytical power, i. e., with the zinc lifted as much out of the battery solution as possible to allow the machine to work ;

and *this* removes the more urgent or prominent *symptoms* of pain and stiffness most readily, and, at the same time, seems to prepare the thus conditioned tissues for the better and more thorough in-working primary current of galvanism, — say, from twenty to thirty Daniell's elements subsequently brought to bear for eradicating, as it were, the dregs of the disease, — that discrasia that seems to be so prone to remain and act as a nucleus for a more ready or easy return of the complaint from slight causes. In fact, this should be kept constantly in mind while treating this class of painful maladies, as it so greatly determines the future condition of the patient.

As a *rule* to guide us as to how long we must wait for the fever and active inflammation to be put out or subside, I find that the larger are the bones and joints which are the seat of the affection, the more boldly we may venture to proceed with our electric treatments; but this not to the exclusion of other means indicated, nor yet neglecting the regimen.

Another *rule* I have also adopted, for being on the safe side, at least, until we know more, and that is, never disturb *old gouty cases* (as we are often solicited to do) while they remain at ease from pain and swelling, but the instant the pain appears, be notified, and that very hour attack it, and never leave until it is subdued and quiet again, and so hold it in check by daily watching and vigilance. But if not so fortunate, if the call is later, or by any means the fever and local inflammation have fairly set in and rage, then other influences must be relied upon until the proper condition is arrived at, that admits of the attempt of the catalytical in-working of the primary current of galvanism.

Hysteria.

Hysteria has historically two significations: the one is *symptomatical*, the other truly *etiological*. When examined under the symptomatic point of view, it is any thing but a rigorously determined pathological condition, so that, in practice, the purely nominal diagnosis is often a deception, in part or in whole, no one knowing exactly what is to be understood by the

term "hysteria." If examined under the etiological aspect, then is hysteria in no wise more exactly specified. Says Professor Schutzenberger, of Strasburg, "If there is a want of agreement as to the range of symptoms, there is still more in respect to their actual cause." In his recently published work on the etiology and pathology of hysteria, he shows from a series of facts investigated extensively, nearly these results, viz., —

1. That a certain *local* nervous excitement, which is generally *continuous*, may and usually does become the organic cause of intermittent functional disturbances that are manifested either as local pain, local or general convulsive attacks, with or without the loss of sensation or motion, — one or both, — but without the central organs of the nervous system, in general, being the subjects of any permanent pathological condition.

2. That, among women, *excitement of the ovaries* is the most frequent cause of this kind of disturbance, acting much as other *reflex* actions.

3. We recognize, clinically, the reality of this cause, since pressure made so as to be deep-seated over the ovaries will induce local pain and reflex convulsive action.

4. Other *local* irritation, or hyperæsthesia, may produce analogous phenomena; an attentive examination for which in each case may discover such centres of irritation.

5. These local irritations, capable of propagating an excitement, when simple and especially when of the ovary, are affections of *curability*, unless they have been long neglected, or are conjoined with incurable organic states.

6. In practice, it is of the first consequence to determine *the source* of the local excitement; then directly to diminish the excited condition of the nerves of the part which form the *focus* or nebulæ whence the local irritation is propagated to the system. The intermittent nervous excitement of freaks, pains, or convulsions, demands but secondary and palliative measures, ceasing as they do when the local irritation is relieved, or temporarily exhausted; unless, indeed, under the influence of the frequent repetition of this propagated pathological *condition*, a morbid degree of excitability of the spinal cord becomes *sec-*

ondarily established, and henceforth capable of being induced by only simple physiological stimuli. In this case there is an entirely new pathological condition. As regards the ovary, the original local excitement there may depend upon congestion or inflammation, on mechanical or physiological *over-excitation* of them, or on degeneration, or a purely neuralgic state. This diagnosis is worthy of our most careful search.

A second series of clinical researches authorizes the reference of a great number of this class of functional disturbances, occurring in the "sensitive sphere," to a special *pathological condition*, whose material element is, as yet, entirely unknown, but which is characterized by an *exaggerated excitability* of the sensitive nerves. The term *hyperæsthesia* is used to designate this condition. We clinically recognize the existence of this organic state when we find that *physiological stimuli*, or *slight causes of excitement*, produce functional manifestations in the sensitive nerves, which appear *spontaneous* or *exaggerated*. This organic condition of the individual nervous system is doubtless sometimes idiopathic, as a part of an original constitution; or it may become developed from errors. At other times it is the consequence of simple anæmia, or chlorotic anæmia. Here, too, we must attack the *cause;* and iron is the sovereign remedy — the most direct galvanic treatment possible for this peculiar state of the organism.

A third series of cases reveals the existence of a more complex pathological condition. Here the hyperæsthesia is associated with a particular morbid condition of the spinal cord, unknown as regards its material element, but characterized by a *pathological excitability*, in virtue of which the *reflex* property of the organ becomes exaggerated, so that we may term this, with propriety, *reflex excitability*. At the bedside it is recognized, —

1. By characters already attributed to hyperæsthesia.

2. There is the existence of a greater or less number of *permanent centres of exalted sensibility, the artificial and mechanical excitement* of which, readily induces reflex movements in the form of convulsive attacks.

In cases of this kind the multiple "points of departure" of the attack in the given case only play a secondary part, and only furnish local palliative indications, the importance of which is in an inverse ratio to the number of the centres of peripheric (secondary) excitements. The fundamental indication, therefore, consists in profoundly modifying the morbid nervous and *organic condition*, which *primarily* revive the functional disturbance incessantly; reducing the hyperæsthesia on the one hand, and a ganglia-reflex extra excitability on the other. This is the cure. Besides other means used to this end, certain it is that *the exertion of the will* may, to a certain point or degree, triumph over this spinal extra excitability. Voluntary motions *methodically* practised, and statedly aided by electro-magnetism, form our best means of overcoming this dreadful state, and restoring to health. (See p. 570, and F, in Appendix-)

M. Briquet, of La Charité, has lately published a paper showing, also, that there are very prevalent errors, both in and out of the profession, as regards the *predisposition* and *cause* of hysteria. He says, "It has been attributed mostly to unsatisfied sexual desires, or to excessive excitement of the uterus or its appendages." The object of the paper is to show, from prodigious research, that these axioms and other old preconceived ideas have no solid foundation in fact, and that the "*hysterical constitution*" has, in truth, only rare existence; the affection occurring, as every one knows, in females of the most opposite external appearance. He gives an analysis of four hundred and twenty five cases, and then concludes, that, at all events, there is no *temperament* that can properly be called hysterical. But that there is a characteristic *moral disposition* — a certain *marked impressionability* — that is even foreshadowed in childhood, as by great timidity, excessive susceptibility to *blame*, and a disposition to shed tears *easily*. The seat of hysteria is not, therefore, necessarily in the uterus; nor is it the prerogative of wealth and luxury, (when *without* abuses;) nor yet is poverty a security against its occurrence. All this has been a complete error; for the common people are found to be subjects of hysteria in almost double the number of those of the other class. Nor are the charms and simplicity of

country life a security against it. In place of a tender childhood, care, and educational influences being assigned, as *pre*disposing causes of hysteria,— exceptions there may be,— it would be far more just to thus stigmatize, if either, *a harassing* or *harsh youthful experience.*

Muscular Hyperæsthesia — "*Muscle-pains.*"

In hysteria, particularly, the muscular system must naturally be expected to play an active part; indeed, the voluntary muscles are a common "*theatre*" for the manifestation of all this troop of phenomena, whether in the form of convulsive paroxysms, in paralysis or debility, anæsthesia, or hyperæsthesia. The most condensed and practical views on this subject we find from the pen of M. Briquet, of Paris, who says,* "The pains expressed in the walls of the splanchnic cavities are of such common occurrence in hysteria, (but not here alone,) that all observers have noticed them, although failing to recognize their true source and seat. They have been usually designated as 'nervous pains,' but without any further explanation; and even the few authors who have recognized them as being *muscular* have failed to appreciate the part that hyperæsthesia of muscles plays in hysteria, or the hysterical subject. From among four hundred hysterical women who were examined particularly in reference to this point, there were not more than twenty who did not exhibit such muscular pains."

Writers upon hysterical affections have passed very lightly over this condition, although it is so constant an accompaniment of the disease, that he thinks there is not a woman subject to hysteria who does not manifest it in one or more parts. But under the term of *hyperæsthesia*, or "exalted *sensibility*," there may be comprised various conditions formerly designated as pains, neurosis, neuralgia, or other painful nervous phenomena. In the present article M. Briquet confines himself to the consideration of hyperæsthesia, as it affects the *muscles*, particularly in hysteri-

* Medical Times and Gazette, 1858, p. 558.

cal patients, although it occurs in others; this being the form which has received the least attention. It is, however, of very common occurrence, and the ignorance that has prevailed concerning it has given rise to numerous and disastrous errors in diagnosis. It may excite surprise to learn that this hyperæsthesia not only constitutes the means of recognizing the nature of hysteria, but is a positive criterion for the decision in doubtful cases.

This hyperæsthesia is so easily recognized by the following signs that it is surprising it has not been sooner appreciated: —

1. The pain is always located in places occupied by the fleshy portions of muscles; or, in certain conditions, at *one end* of their tendinous insertion.

2. As the superficial muscles are those usually affected, it is felt *immediately beneath the skin.*

3. Slight pressure, or scratching with the end of the finger over the affected muscle, induces or aggravates the pain.

4. The pain thus induced is very severe, causing often cries or contortions on the part of the patient, or even an hysterical paroxysm.

5. Movement, and especially distention, of the fibres of these muscles, produce or exasperate the pain, while rest abates or relieves it.

6. Feeble electro-magnetic currents, which scarcely produce a sensation elsewhere, — i. e., when travelling through the length of a muscle that is in a normal condition, — will induce an amount of pain that is difficult to bear while traversing the hyperæsthetic muscle, and becomes quite intolerable when the current is made a little stronger.

7. Under the influence of proper Faradaization, non-inflammatory muscular pains, including also such as the rheumatoid, and those of lead-colic, and especially those arising from a pure hyperæsthesia of muscles, (in men or women,) are now known to be rapidly dispersed. But we find that this hyperæsthesia — which, indeed, may be termed "*hysterical myoalgia*" — is not found to affect all muscles alike; the superficial muscles, and particularly those of the trunk, being the most liable to it. In

the body itself, it has its places of preference, which it observes with so much constancy and regularity as to serve for one of the diagnostic signs of hysteria. The following may be marked as its favorite seats, and succession of order of attack: —

I. *Cephalalgia.* — When the hyperæsthesia affects the muscles of the head, it constitutes what has been termed cephalalgia. So common is this in hysterical patients that, out of three hundred and fifty-six of these, it was found habitually, or at least very frequently, in three hundred of them, as affecting especially the frontal and temporal regions of the head, and, in at least nine tenths of the cases, as having its seat in the fleshy portions of the muscles. It is frequently *pulsatile;* at other times, *lancinating*, and continuing even during rest in bed, which distinguishes it from the anemic and chlorotic headache, which, on the contrary, is hardly felt except during motion. (See p. 420, & App. D, 2.)

II. *Rachialgia.* — Hyperæsthesia affecting *the muscles of the back* has been long recognized, (in men, sometimes, as well as in women.) So common is it, indeed, in the hysterical patient that M. Briquet found it absent in only five out of three hundred and eleven cases. According to the details he gives, it is found five times more frequent at the lower part of the back than at the upper part, and as many times more frequent on the *left side* than on the right side of the spinal column. It occupies, in general, a space corresponding to about four or six vertebræ. It usually appears here *subsequently* to the epigastralgia, and may then exist, in various degrees, from a mere uneasiness, scarcely perceptible, unless pressure be made at, and along the side of the spine, over the severest suffering, and consequent source of disturbance of important functions. When intense, it becomes more fixed, and is then one of the "symptoms" of hysteria that is most difficult to remove, the pain recurring from time to time from the slightest cause. Its diagnosis is easy, by means of pressure made on the muscles at either side of the spine, and a little distance from it, until found, and then by observing *its usual connection with epigastralgia, and other symptoms of hysteria.* In spite of this, however, its presence has frequently given rise to the most serious errors, and a frequent one among

these has been the mistaking it for an early *sign* of phthisis. What authors have described as "*tabes-dorsalis*" has most often been but this rachialgia, reacting upon the viscera, and vitally affecting nutrition, as it will, (in males as well as females.) But the most serious of all these errors is, the mistaking it for *disease* of the spine — an error Dr. Briquet believes to be even more common than Sir Benjamin Brodie has represented it to be.

III. *Epigastralgia.* — Hyperæsthesia of *the muscles of the epigastric region* plays a far more important part than has been suspected. It frequently occurs, says Dr. Briquet, as it has been noted in three hundred and seventeen out of three hundred and fifty-eight hysterical subjects. In one hundred and thirty of these, there was no accompanying derangement of the digestive functions, while, in one hundred and eighty-seven, such disturbances did exist. In answer to the question, why there should be so constantly pain in parts which seem to have no relation to the moral emotions of the patient, it may be observed — (1.) Epigastralgia may be met with in the childhood of girls who are subject to ill treatment, (*or who are constitutionally peculiarly sensitive to blame*,) or who have an hereditary predisposition to hysteria; and in such it becomes associated with disorder of the digestive organs, and a disposition to *migraine*, (hemicrania.) (2.) In others, it appears either at the period of the establishment of the menses, or later, and during difficult menstruation. (3.) In a certain number of cases, it arises amid the disturbances produced by chlorosis. (4.) In a few instances, it arises during the actual evolution of the hysteria, without the aid of any special cause. Now, the above-named circumstances explain the origin of one half the cases of epigastralgia; and the other half is due to the two following orders of causes: —

(5.) First, the disguised or manifested hysterical paroxysms. These are usually preceded and accompanied by a feeling of compression, distention, or even tearing, and distress in the epigastric region; and for twenty-four hours after the fit is over, the patient often complains greatly of epigastric pains. In proportion to the repetition of the paroxysms does the epigastralgia become established.

(6.) Second, the depressing moral emotions. These, when at all intense, produce *painful constriction* of the epigastrium. To sum up, this muscular hyperæsthesia is due to the two orders of physiological causes, namely, the direct influence of the nervous centres on the muscles, and the reaction of the disordered stomach on the same muscles.

Epigastralgia extends peculiarly towards the left side, rising as high as the sternum middle, and rarely descending below the umbilicus. The pain is severe and continuous, and easily exasperated by emotion, progression, compression, or the hysterical fit. The attitude is constrained, and sometimes the respiration is influenced; but here the process of digestion does *not* appear to aggravate the suffering. The ignorance that prevails as to the seat and nature of epigastralgia has led to most serious errors in medical practice — these muscular pains being sometimes vaguely thought to be localized in the solar plexus, and, at others, in the stomach itself; and then, according to the doctrine of the day, have been treated as neurosis, gastralgia, or gastritis.

Now, if we bear in mind that, in somewhat less than half of the persons suffering from pains in the epigastrium, (stomach region,) the pain is only *muscular*, it is evident that that number, at least, have been treated for a gastralgia that had no existence. Moreover, in patients suffering simultaneously from epigastralgia and derangement of the digestive functions, the former may exist independently of the latter, and be easily relieved by means addressed specially to it; and yet, in these cases, the stomach has been needlessly tormented by treatment that, rather, should have been directed to the muscles. It is not meant to be said that the stomach itself may not be the seat of severe suffering, such as pyrosis, tearing pain, or distention, from indigestion; but such pains are intermittent and temporary, and should not be confounded with the *continuous* pains of the epigastric muscles. The writers on gastralgia never allude to these "muscular pains;" and, since amid three hundred and fifty-eight cases of hysterical patients the author found not above ten in which gastralgia existed without epigastralgia also, it is easy to

see how often the stomach has been rendered responsible for ills that did not attach to it. This affection of the muscles may continue as long as hysteria can, and persist to very advanced age. When it persists with intensity, the constant pain wears out the patient, rendering at last all active movements quite insupportable. She perhaps becomes melancholic and emaciated, and presents all the appearance of premature old age. Fortunately, we can now say, nothing is easier than the relief (cure) of this affection, under appropriate treatment. (See App. G, Note 2.)

IV. *Pleuralgia.* — Pains in the *muscle fibres* at the side of the thorax are so common, that they have been familiarly noticed by all observers; but they have always been confounded with the true neuralgia. In the hysterical female they are most common, having been found by M. Briquet in two hundred and twenty-three out of three hundred patients in whom such were sought for. The seat of the pain here is rather fixed, extending usually as a semicircle, corresponding to the fifth, sixth, seventh, or even the eighth ribs, sometimes following their direction, and at others being still more oblique. This is found six or seven times more frequent on the left side than on the right, and he found it bilateral in only nineteen of the above cases. It usually comes on subsequently to the hyperæsthesia of the other parts that have just been mentioned, it forming, as it were, but an extension of them. *Hysterical pleuralgia* can only be confounded with the pain of true pleurisy; it suffices, however, to be aware of the possibility of the former, and the then usual coexistence of epigastralgia and rachialgia, to prevent any error. It is perhaps more readily confounded with intercostal neuralgia, by which name many cases of this hysterical pleuralgia have been erroneously indicated. The distinction between these two is: First. The hysterical or muscular hyperæsthesia does not follow the direction of the nerves and their branches, but is *invariably* found at the fifth, sixth, and seventh ribs, while the accompanying rachialgia and perhaps epigastralgia are situated quite above the points they should be, *if* dependent upon neuralgia. Second. The pain bears no resemblance to that of neuralgia, for it is excited at any point that is compressed, *without radiating*

along the course of the nervous tracts. Third. Neuralgia, after setting out from this point of origin, may very soon extend to other divisions of the affected nerve. Hysterical pluralgia only shows itself *after* epigastralgia, and then rachialgia also has already long existed. Pluralgia (muscular hyperæsthesia) usually constitutes only a more or less considerable inconvenience, and however long it may persist, it is at last dispersed without inducing phlegmasia of the contents of the thorax. (See G.)

V. *Thoracalgia.*—Among the four hundred cases observed critically, only twenty-seven complained of *pain in the muscles* at the anterior part of the thorax. In twelve of these it occupied only the left side, and in two, the right; while in thirteen, all the anterior portion of the chest was affected. This form of hyperæsthesia is usually one of the last that appears, and its rarity is probably due to the slight part which the pectoral muscles (wherein it is seated) take in the expression of depressing emotions. This form is not very persistent, rarely disturbs respiration, but recurs from time to time, and gives cause to much anxiety from the patients fearing that they have disease of the heart. Its independence of neuralgia may be judged by the fact that of one hundred and fifty hysterical patients with rachialgia at the level of the first six dorsal vertebræ, only twenty-seven complained of pain at the anterior part of the thorax.

VI. *Cœlialgia.*—The *muscular hyperæsthesia* of any patient is so termed when it has its seat in the walls of the abdomen. The pains of this character have long been known to authors, but they have been attributed to lesions of the sympathetic nerves, or ascribed to the underlying viscera. The author met with it in one hundred and ninety-six of four hundred cases of hysterical females. In forty-two, it affected both sides; in seventy-six, the left side only; and in thirty-four, the right side alone. This pain usually engages a considerable portion of the muscles affected, and is *continuous* while in the erect posture, being much increased by movements or pressure, but relieved by lying down and keeping still. In many instances this affection has been sadly mistaken for painful affections of the ovary; and it is such mistakes that have given rise to the supposition

that ovaritis is of more frequent occurrence on the left than on the right side. But the search for the superficial character of the pain ought to prevent this error being committed. If we first relieve the muscular pain, we find we can press over the ovary without pain. The duration of hyperæsthesia in this seat is very variable; the condition and exercise or *habit* of the genital organs, as also the amount of any sort of exertion or of repose taken by the patient, vastly influencing this result. These patients are often much distressed by this pain, being led to believe it to be indicative of some uterine disease. (G, Note 4.)

VII. *Melyalgia* (a limb) is the term applied to *painful muscular hyperæsthesia* of the superficial muscles, and sometimes of the deep-seated muscles of the extremities. The existence of such pain, particularly in hysterical females, has been noticed by authors only in a vague manner. Among my four hundred cases, only fifty-eight examples of it occurred; of these both upper and lower extremities were affected in thirteen of them; the upper alone in twenty-one; and the lower alone in twenty-four. It varies in degree from a mere disagreeable sensation to most severe suffering, destroying all repose, and, if not relieved, it even gives rise to fever. In spite of the most unfavorable appearances, however, it quite disappears, sooner under the influence of correct treatment, or later, perhaps, spontaneously. It cannot be confounded with neuralgia, seeing that in two thirds of the cases the locality of the pains does not correspond with the origin of the nerve branches distributed to the muscles affected; while from true neuralgic pains arising from affections of the nerve trunks, nerve branches, or centres, muscular hyperæsthesia is distinguished by its being aggravated simply *from pressure on the muscles*. (See Notes A, B, C, p. 475, and Appendix.)

The distinction of this affection from rheumatic myosalgia is often more difficult. The diagnosis here must be drawn from the nature of the pain and the attending circumstances. The pain in hyperæsthesia is usually excessively intense, the slightest contact causing very severe suffering; while the muscular rheumatic pain is much less increased by pressure, and this, too, must be firmer in order to produce it. The hysterical pains of this sort

are found manifested in women who have already presented other symptoms of hysteria, and they almost invariably coincide with other muscular hyperæsthesia. The emotions also exert very great influence over them; while rheumatic muscular pains usually appear in women who have already suffered from muscular rheumatism, and are in degree exasperated under the influence of *emotion*. The difficulty in this diagnosis is the greatest, where the patient is both hysterical and rheumatic, which I have often found. But then the influence, or rather *inefficiency*, of the means, which so usually succeed in the simple hysterical myosalgia, is sufficient to determine the complication of the rheumatic character of the affection in that given case.

Two important points still remain in respect to melyalgic pains. First, does it arise from any inflammatory action, or from mere *perversion* of muscular sensibility? or, rather, from a morbid sensibility of the motor nerve filaments that ramify muscle fibres? Leaving the flood of opinions written upon this subject, we will simply answer by the effects of treatment. Melyalgic pains are no ways relieved, much less broken up, by antiphlogistic remedies, only yielding temporarily or capriciously to narcotics, and can usually only be relieved by such special means as have no favorable effect upon inflammation. Second, is this pain a muscular neuralgia? This, at first, is a very natural supposition, but it is in fact unfounded. True muscular neuralgias act exactly as do the pains of nerve trunks, and are indeed *very rare* in the uncomplicated hysterical. Numerous differences mark this affection of the muscle nerves or muscle tissues, as you may choose to term it, from an exquisitely morbid or *exalted* sensibility of the skin nerves, which latter, besides other points, it is to be particularly observed, manifest the pains at the periphery of the nerves, but not in the intermediate portion; while in true hyperæsthesia of muscles the pain is felt, and can also be produced by pressure along the entire course of the fibres of the affected muscles. In this latter, pain is only felt at the part compressed; while in neuralgia it can be induced by pressure *on certain points*, and it then radiates along the course of the branches of the affected nerve. But the best test

is the effect of correct treatment; for while the muscular hyperæsthesia, which is manifested by pain, is always removable, nothing can be more obstinate or tenacious of its own peculiar display, than the fierce twinges of true neuralgia.

Finally, whenever we observe very acute pain to be induced by simple pressure of the finger on a muscular part of the body exhibiting no traces of inflammation, we may, from this very sign alone, diagnose the presence of that peculiar state of the system termed hysterical, with a very great degree of certainty. Whenever we are in doubt in these cases, we have only to gently rub with the end of the finger, for instance, on the upper end of some of the *recti* muscles in order to become perfectly convinced. Indeed, hysterical myosalgia, in some of the various forms here noticed, is, in fact, one of the most marked symptoms of hysteria, (to our own mind, though it may not always be best to declare it,) for, as it is almost never absent, it may itself be set down as a characteristic mark of this peculiar state of the system. Observation has, of late, fairly proved that it is rare not to find in these patients this peculiar muscular hyperæsthesia, either at the epigastric region, or high up on the back, or low down on the bowels, or sides, and that particularly on the left side; and, in a very great majority of cases, it appears in all these situations at once; and every female presenting this almost stereotyped series of symptoms may be most positively declared (or, perhaps, more prudently, *thought*,) *hysterical.*

From what has now been said upon the high authority of Dr. Briquet, we fear it will be well nigh inferred that "muscular hyperæsthesia" is limited to the female sex, and to cases of hysteria. By no means is this true. Most marked, distressing, and protracted cases of this malady in gentlemen of the professions, in those of close business habits, and those especially in the higher walks of life, are as familiar to the author as the class just delineated, and are found quite as amenable to right treatment, and, by far, less likely to relapse. Nor, indeed, to my mind, are all the cases that present in females (in this country) to be put down either as hysterical, or in any way connected with *uterine deviation*, as necessarily so. It is my own

observation that those painful affections of the muscles very frequently occur in both men and women, and may arise from a multitude of causes. Strong or long-continued "emotional feelings," *particularly such as are unpleasant*, or harassing, or any way nerve-exhausting, are capable of harrowing up this singular demonstration either in man or woman; and the *more impressible* the existing sensibilities or mental faculties, or the more *feeble* the muscle fibres are from want of exercise, or from over-exertion, the more liable is he or she to this painful, and, doubtless, often mistaken affection. There is not a question that the *habitual* indulgence in mere *thoughts* of venery may also produce it, and much more the habitual excess. Besides, it is no uncommon thing to find these cases complicated, or, rather, *mixed* with some rheumatismal or neuralgic manifestation, or else attended with cramps, or spasms of the muscle fibres; but this, more particularly, in females. Debility, — *debility, with nervous irritability, and this with over-mental or over-manual work, — is at the bottom of the whole.*

One other important fact should be noticed; and that is, that when this kind of pain appears to be the result of *over-exertion* of muscles, whether that was too great or too protracted, or from the muscular strength being below par, and inadequate to the task, then the seat of these pains is rather referred to *one insertion* of the muscle or muscles, but rarely to both insertions; and in that case, never to the fleshy body of the muscle. This fact, I believe, was first noticed by Dr. Inman, of Liverpool, who says that in the weak-muscled, or in the over-worked, it is not uncommon to find that both insertions of the muscles suffer equally. That it is really so, recent experience proves, though it affords no adequate explanation of the reason why. Thus, in excessive cough, one patient refers the pain to the origin, another to the insertion, of the *pectoralis major* and *minor;* one seamstress refers all her pain to the occipital, another to the spinal, another to the scapulo-clavicular attachment of the trapezius muscle. One refers her pain to the infra-mammary, another to the inguinal, and another to the semilunar attachment of the external oblique muscle. One refers his, or her, sufferings, perhaps, chiefly,

if not entirely, to the pubic, and another to the epigastric attachment of the *rectus abdominis*, while others refer their complaints equally to all these spots simultaneously, or in succession.

Treatment.—For the "*muscle pains*" of *muscular hyperæsthesia*, in both men and women, but particularly in the hysterical female, resort has been had by physicians, from time immemorial, both to the antiphlogistics and the antispasmodics—the anodynes and the revulsions—to topical emollients, cataplasms, liniments, &c., &c. After a persevering employment of these classes of means, and this under the widest facilities, M. Briquet says he finds they are really of little or no permanent use whatever, as any benefit that has at times seemed to accrue, after all, depended much upon the *temperature* at which they have been applied. Narcotics give a precarious amelioration, and that is all that is procured from them. Even these, then, require to be varied, and after all are but little to be relied upon. The *condition* for pain is still there.

The truly heroic remedies in all muscular hyperæsthesia are the *stimulants*. Dry heat, applied by cloths as hot as can be borne; very hot cataplasms, and chloroform, which acts more as an irritant than as a narcotic; sinapisms, which are still more effective if applied for ten or fifteen minutes, and two or three times a day at the same place,—very frequently relieve the pain. Tincture of iodine, or of capsicum, repeated twice a day, will speedily succeed in some. Blisters, after all, have more power, usually, than all the preceding list of *stimuli*. (See G, Note 5.)

"*Faradaization*" of the skin, as performed by Dr. Duchenne, is, after all, *the means*, *par excellence*, for all these cases, according to the experience of Dr. Briquet. By this kind of electric current, he says, *if strong*, *and limited to the affected muscle* for but a few minutes, the hyperæsthesia is sometimes at once dissipated; and when this is the case, even firm pressure, or movements of various kinds, fail afterwards to induce any sort of pain. Not infrequently a single application suffices; but sometimes the pains return at the end of an hour, but more commonly after five or six hours. *If they have not returned by*

this last-mentioned period, we may be certain that the cure is definite. When they do thus return, the application must be repeated as strong as can be borne, when the pain will be found to become feebler after each *seance.* If, however, after two or three fair trials, success has not in any degree attended them, the application must be renounced. The conditions for success of Faradaization with electro-magnetism are, the recent date, the diffusion, the superficial seat, and the moderate intensity of the pain. Still, as there are cases in which, though the pain has been there of old date, and success from this treatment in such has taken place, it should always be tried, for it is certainly with some chance of benefit. As a *general rule, hysterical females bear the sharpest Faradaization with far more courage than men;* but still some of them are so exquisitely susceptible, that its employment, if *urged* upon them, may even induce paroxysms of hysteria. In such cases it is recommended to let her previously inhale ether, as it in no wise impedes the peculiarly revulsive action of Faradaization. During the treatment of this affection, one grand condition must be, the complete repose of the hyperæsthetic muscles. This is, under all circumstances, of prime necessity. From ignorance of the true nature of this affection, *exercises* of various kinds have, from time to time, been recommended! Absolute repose is one essential to the cure; and a few days of such, sometimes, is of itself sufficient to relieve those pains that have resisted most energetic remedies. There should be a general or medical treatment, therefore, as well as the "*electrical.*" (See p. 475, and Appendix.)

Neuralgia.

M. Valleix was the first to point out the great fact, as regards *true* neuralgic affections, and which seemed to have escaped the notice of all previous medical observers and that was, that the *superficial nerve trunks*, and those that *emerge* from bony canals, are those most commonly affected; also, that there are certain other "*painful points*" in the course of a nerve which are more liable to be affected by this kind of pain than any

other portion of the nerve. Dr. Valleix, by special research, thought he had demonstrated "*four several points*" on the course of a given nerve that are most likely to be the seat of neuralgia, or, rather, where the neuralgic pain is more liable to be manifested. According to him, the four marked points are as follows: —

1. "The *first point* where a nerve is apt to show pain, is *at the place where the nerve emerges* from the bony canal through which it passes: *the nerve is affected here*, and here it is tender to pressure; but the neuralgic suffering may be ascribed by the patient to this point, or elsewhere along the course of that nerve.

2. "The *second point is where the nerve trunk suddenly becomes more superficial*, or runs along near the integument.

3. "The *third point*, that is prone to show this pain, *is where the nerve branches traverse the muscles* to reach and become ultimately distributed superficially in the skin and fascia.*

4. "The *fourth point is where the terminal nerve twigs are spread out to be lost in the integuments*."

Now, it is important to notice that this most valuable information, although not perfect, puts us on the right track, and enables us to find, usually, the exact place, where the *tenderness from gentle pressure* indicates the nature of the affection, and the propriety of local applications.

We notice that Dr. Duchenne, of Bologne, as also M. Brown-Sequard, and others, are lately disposed to regard *neuralgia* as a veritable "*discrasia*," much like that in gout and rheumatism, which in one person determines to the *neurilemma*, more particularly along the larger nerve trunks, and so causing true neuralgic pains; while, in other persons, this *discrasia* has an *election* for the great toe and the condiles of the joints, and so producing that other class of very peculiar pains which characterize a fit of the gout; and yet still, in other persons this discrasia has rather an *affinity* for the ligaments of joints, *bursæ* of the tendons, and the *periosteum* of the bones, which characterizes the

* The author defines this point, and some others, still more closely.

pains of rheumatism. That special condition of the body which gives rise to shifting pains which are sometimes seated in the muscles, (muscular hyperæsthesia,) at others about the joints, (neuralgic rheumatism,) at other times in the joints, (rheumatism,) &c., seems to favor this idea. It may be exactly true, or it may not, however, for as yet it is not further demonstrated. Dr. Alfred Smee, of England, and Dr. De la Rive, of France, are of the opinion that neuralgia arises from a *material* disturbance in the natural nervo-electric state of those nerves affected, or of the whole nervous system, where is shown the neuralgic diathesis; and that the disturbance is more usually at the *peripheric* nerve pole; but what that disturbance is, precisely, no one is able to define.

If we comprehend under this head all those very painful affections, wherever seated, which are apparently unconnected with inflammation, and which are not the result of some important or discoverable lesion, we shall find a large class, that doubtless arise from the encroachments or compressions of blood vessels upon the nerve trunks, just as they pass together through bony canals. This distention of the blood vessels may arise either from an extraordinary flow of blood in the arteries, or from a faulty or *sluggish* return of blood through the veins; it may occur, then, where there is too much blood and too great a distention of the vessels from the quantity; *but more frequently* does it occur from the venous congestion, "stasis" or stagnation from atony, i. e., from impoverished blood, and *from deficient enervation* and want of tone in the tissues. Exposures to sudden cold, as well as traumatic causes, also produce it.

Since the commencement of the present century, neuralgia has been distinguished from rheumatism and gout. At first the study of this class of pains was limited to their occurrence in the face and lower extremities, and then the terms "*tic douloureux*" and "*sciatica*" were generally applied; but more recently the term "neuralgic affections" has been extended to all morbid exhalations of sensibility, or excruciating pains in parts not manifestly inflamed.

Neuralgia may be defined as violent pain in the trunk or

branches of a nerve, occurring in paroxysms of irregular duration, and after regular or irregular intervals. The pain is sometimes slight and obtuse at its commencement, and then augments in violence, becoming sharp, darting, or lacerating, which is attended with a peculiar and excessively acute plunging or constrictive sensation, which darts at intervals through the painful part. But more frequently the attack of pain is sudden, which is sometimes preceded either by an itching, tickling, prickling heat or numbness, or by slight and fugitive pains ; any of which may recur whenever the paroxysm of pain is less.

It may be confined to the very *trunk* of the nerve, but as often extends itself to the integumentary ramifications, and even to the terminations of the nerves in the superficial muscles, (muscle hyperæsthesia.) Sometimes it affects only a few of the branches of a nerve, or even one or two, merely, of the fibrils.

When severe, an attack of neuralgia may be attended with tremors, or spasms, cramps, or convulsive motions of those muscles depending on the affected nerves ; but there is neither redness, heat, nor swelling. When these latter phenomena do occur, it is a more or less *neuritis*, or inflammation of the nerve. The paroxysms may be extremely variable, sometimes intermitting, at others remitting, occurring after regular or irregular intervals. A person who has once suffered from it is liable to its return, although he may have been completely restored. The malady is acute as regards the paroxysms, but so great a liability to their recurrence makes it generally considered a peculiarly chronic disease.

Neuralgia, then, is most liable to affect those nerves of the head, trunk, or extremities, *which are located superficially*, and hence are most exposed to vicissitudes, and such as are surrounded by bone or loose cellular tissues. Neuralgia may also affect the visceral nerves, as those of the heart, diaphragm, stomach, liver, spleen, bowels, uterus, kidneys, testicles, &c. And muscles, (like all other organs which receive mixed nerve filaments with motor nerves, that emanate from the cerebro-spinal axis,) *enjoy* in health, and *suffer* in disease, a sensibility *peculiar to muscle fibres*, if still in communication with the spine and brain

by appropriate telegraphing nerves. This muscular hyperæsthesia, although less acute than that of the skin, is, however, susceptible, like the latter, of increase, of diminution, and of abolition.

Facial neuralgia, or "*tic douloureux*," is an affection whose pathological and symptomatic phenomena can be stated only in connection with the morbid exaltation of sensibility of which it is constituted. The suffering is generally referred to one of the three branches of the *tri-facial* nerve, (the fifth pair,) and darts along the ramifications, so that the precise spot or tract can be indicated by the patient. But it occurs more frequently in the two upper branches than in the inferior maxillary branch. When seated in the *first* or *ophthalmic* branch, the frontal ramifications of it are oftener affected (brow-ague, or *clavus hystericus*) than the *lachrymal* or nasal; but, in some cases, it involves all these — there may be a superabundant secretion of tears, or pain in the eye. When the *second*, or superior maxillary branch, is the part involved, then the *infra-orbital* is the seat of suffering, and that more generally where the nerve passes out from that foramen; or the pain may radiate from there, or it may be expressed mainly in the upper lip, or *ala* of the nose, or in the gum. If the posterior dental ramification of the second branch is the seat of the affection, then the attack resembles the most awful toothache. If the *tic* is in the third branch of the tri-facial, it is manifested in the inferior dental nerve; and more usually in the mental portion where it *emerges* from the mental foramen on the chin, and the pain extends to the inferior lip. It sometimes extends through the branch that communicates with the seventh pair, and thus implicates it. The pain may be seated rather in the *anterior auricular* branch, and then extends to the temple in the course of the temporal artery. The pain may extend to the lingual branch.

During the paroxysm of facial neuralgia, the muscles of the face are often contracted on the affected side. The least motion, noise, or light aggravates the pain; usually there is no febrile commotion in the system, and no acceleration of pulse, even during the most intense suffering. The duration of

neuralgic pain may be but an instant, a minute, or an hour, or even longer. It may terminate as suddenly as its attack. It may be liable to recur regularly, or irregularly, for a very great length of time. It may cease for months, or years, completely, and then return, unasked, even more severely than before. The most trivial circumstance may be sufficient to *bid* it *up*, — such as vicissitudes of temperature, a moral emotion, or a sudden faulty function. (See Appendix D.)

OTALGIA, or earache, and ODONTALGIA, or toothache, frightfully painful as they are, may be, and very often are, simple neuralgic affections. But the toothache is more frequently referable to some source of irritation in one or more of the teeth, or on the antrum or gums. But often without these more obvious causes, and as often in connection with them, an attack of toothache is brought on by the very same causes, and in the same way, as those which produce other forms of neuralgia; the local source not being sufficient in itself to develop this morbid manifestation. If it is attended with inflammation, then electricity is not indicated. If there is ulceration, or caries, it is likewise useless, except perhaps for the temporary lull. But when the attack is in the gouty or rheumatic, and the affection is truly in the *antrum*, *nerve*, or *periosteum*, then an electric current can relieve like a charm; and that more uniformly, and for more permanency, than any other means I ever employed. The pain in the ear, that is characterized as neuralgic, appears to be seated in the *chorda tympani*, and perhaps also involving the acoustic nerve. It is often associated with a *face-ache*, or neuralgia of the face. The pain in the ear is unattended with inflammation, but is accompanied with noises in the ear, and sometimes with temporary deafness. (See D.)

Neuralgia of the *cervical nerves* is perhaps quite as common; and cases do now and then occur from puncture of the nerve in bleeding from the jugular vein, or from leech bites. But a more moderate and remarkably persistent kind of neuralgic-rheumatic affections of these nerves and their depending muscles is frequently observed. These are more chronic; in some cases and respects, more resembling rheumatism, while in

others neuralgia ; and are often attended either with contractions or spasms of some muscles, which may prove temporary or permanent. Beware of a *caries* of the upper cervical vertebræ. Take counsel of the *history* of the case.

Neuralgia of the *occipital nerve*, which may also be attended with stiffness of the muscles of the neck, is often a very painful and tedious affair. A very distressing case, of long standing, of this kind, sent me by Dr. R. H. Storer, has been greatly benefited by electro-puncture. I inserted two needles very deep on each side of the upper cervical vertebræ, so as to embrace in the current the long, posterior ganglia, or at least the roots of those seven or eight small branches of nerves that leave these ganglia near the posterior arch of the atlas, and which, it is well known, are distributed to the muscles of the upper and back part of the neck and head. (See D, Note 2.)

Neuralgia of the thoracic or *intercostal nerves* is often presented in both sexes, either amounting to true neuralgic acuteness, or hardly more than a rheumatic aching, (muscular hyperæsthesia,) or perhaps attended with passing spasms. They may arise from vascular congestion of a portion of the spinal cord, or of its membranes, or from actual inflammation or other morbid state in those parts ; but this latter is not so positively agreed upon. Besides, there are very many painful cases that affect the thoracic and abdominal nerves, and their depending integument and muscles, without any corresponding evidence of irritation, congestion, or inflammation of the cord ; while, on the other hand, evidence by post mortem actually shows these disorders of the spine, in other cases, which had been entirely unsuspected, by not being manifested by more painful expressions.

Thoracic neuralgia shows itself about the seventh, eighth, and ninth ribs, at the spot where they unite with their cartilages, and that mainly on the left side. This indeed constitutes the familiar "*infra mammary pain*," which the author has found is by no means peculiar to females, and hence is not necessarily *hysterical*, even when it occurs in women ; although it is equally true that very many of those cases do seem to be so

characterized. The pain darts in the course of the nerve, sometimes to the spine, and embarrasses the respiration. It is occasionally attended with pain in the epigastrium, or bowels; and in women there is *hysterical colic*, or pains in the region of the ovaries or uterus. The pain may be diagnosticated from rheumatic by the former *showing great sensibility of skin*, and the latter showing soreness of the muscles, by pressure, or in using them. It occurs more usually in the *left side*, and but rarely in both sides at once, or in succession. (See G.)

Intercostal neuralgia is a very frequent complaint. According to the careful researches of Dr. Valleix in this department of pathology, or rather *abnormal physiology*, he found these pains rarely in the first and tenth spaces, and in the eleventh and twelfth never. This kind of pain is increased on pressure, by full inspiration, or by cough, but not equally so along the whole course of the nerve. There are *points* where the pain is acute. These are, first, a little one side from the spinous processes, where the nerve passes from between the vertebræ; second, at the anterior portion of the intercostal space, and near to the epigastrium and sternum; third, about the middle or arch of the ribs. The pain may be dull, aching, or a mere sore feeling, and be persistent; or it may be sharp, darting, and often recurring. And here is the proper place to class and include all those cases usually denominated "pleurodynia." Intercostal neuralgia is often connected with the hysterical condition, and disordered digestion. It is also found to arise from over-work and from exposure. But probably the greater source is, *impaired nervous energy*, and at the same time *an irritation of some portion of the organic nerves*. Besides, as we have said, it may, or may not, be connected with, or arise from, a positive venous congestion of a corresponding portion of the cord, or rather of its investing membranes. (See F, G.)

Such are the facts in regard to the cervical, thoracic, and abdominal branches of the cord; but if we pass down to the lumbar region, we often meet with pains here other than the true neuralgic. M. Chaussier describes life-like cases, that refer the pains to the kidneys, ureters, bladder, or uterine organs.

34

Sir Astley Cooper, however, in his work on the Testis, (p. 110,) gives some cases of *tic douloureux* of the spermatic cord. He believes the pain to be truly *seated in the nerves*, as the pains dart only along their route. He states that he carefully dissected all the testicles which he removed on account of this fearfully painful affection; but there was found no kind of structural change in any of them — proving that they were actually neuralgic. (See Appendix E, Note 1.)

Both the aggravating and alleviating agents and circumstances, lead us to see that "lumbago" is, after all, more nearly allied to neuralgia than to rheumatism, in respect to the character of the pains, and is referable, in a great majority of cases, to impeded venous circulation in that portion of the spinal cord that is below the origin of the *cauda equina* at the second lumbar vertebræ, and evidently now and then involving also the roots of those nerves that supply the lumbar muscles. If the anterior branch of the first lumbar nerve is involved, the pain extends from the loins and crest of the ilium to the groin, the spermatic cord, testicle, or scrotum, or to the labia of the vulva in the female. (See p. 477, and Appendix B, E, F.)

Neuralgia of the upper extremities is more frequently found seated in that portion of the *cubital nerve* at the elbow, which passes between the internal tuberosity of the humerus and the olecranon, from which spot the pain darts down in the route of the nerve, even to the ring and little fingers. Sometimes the pain starts from the *brachial plexus* and shoots backwards through the *supra-scapular* nerve, but more frequently through the *sub-scapular* nerve; and still more frequently through the nerve *circumflex;* the pain then being seated in the back and lower portion of the deltoid, and near its insertion into the humerus. A most excellent and somewhat aged lady, who had suffered from this painful nerve for about two years, in spite of skilful care, was sent to me by Dr. J. B. S. Jackson, and was entirely cured of it by a dozen sittings for the primary current of galvanism, aided by electro-puncture. Some exceedingly painful and protracted cases of neuralgia of that branch of the *median* nerve that ramifies the dorsal aspect of the thumb, have

presented, showing the seat of intense pain mostly in the thumb, at its side, or about the root of the nail. (See p. 477, B, 2, 3.)

Neuralgia, uncomplicated, of the lower extremities, is, perhaps, most frequently observed as most severe when it occurs in the *sciatic hollow*, between the great trochanter and the ischium. The pain is either fixed there, or shoots along the course of the great sciatic nerve, or shows itself at the femoro-popliteal nerve, extending, in one case, upwards to the sacrum, or, in another, and more frequently, downwards, even to the ankle and foot. Now, this whole family of sciatica was for a long time classed with rheumatism, until M. Chaussier and others demonstrated that there is here essentially a form of neuralgia, although at times the given case may show an alliance equally with inflammation or rheumatism; but these latter are by far the more rare. It was also formerly confounded with all kinds of painful affections of the hip region, whether inflammatory or rheumatic, primary or symptomatic — all were called *sciatica*. But true sciatica must be sifted out from these to be viewed and successfully treated, first as inflammatory, and then as neuralgic. In these the greatest suffering is sometimes in the anterior tibial branch that terminates at the great toe; but oftener still in the peroneal branch of the *external popliteal*, which is one of the continuations of the great sciatic nerve, and terminates on the outer side of the foot. The accession may be very sudden, but it is usually preceded by a painful prickling or a numbness along the thigh, or down outside the *fibula*. Only one limb is usually affected. The slightest cause may bring on anew the paroxysm of pain, as the warmth of bed, mental emotion or excitement, motion or exertion. The continuance is as tricky and uncertain as other neuralgia. Where it has been long standing and severe, there sets in a lameness, and some *dragging of the limb*, with a partial palsy and wasting of the muscles of the limb. There, then, may also be trembling of the limb or *formicans*. (See p. 476, B.)

Neuralgia of the *femoro-pretibial* occurs less frequently than sciatica. The *seat* of pains affects the great trunk of the *anterior crural nerve* as it passes out from under Poupart's ligament, or the crural arch at the groin, and before it so abruptly divides

into its many cutaneous and muscular branches. The pain then darts along to the middle of the inner thigh, or to the inside of the knee, or it may trace along the internal *saphenus* nerve, which is the main continuation of the anterior crural, down the inner side of the leg to the inner ankle. Those minute branches of this nerve that are distributed about the *lower edge of the patella* were the seat of most excruciating attacks of neuralgia for years, in a gentleman of eminence in Cambridge, whom the author cured more than a year ago by electro-magnetic currents. The morbid action in this case was first set up by hitting the knee against the steps of a railway car. In another case, a young lady fell up stairs, and struck the knee about two inches above the patella, which hurt her somewhat at the time, but it was soon forgotten. For several years past she has been more or less lame, and subject to paroxysms of most excruciating pain in a point just below that knee, which extended up to Poupart's ligament, and the anterior crest of the ilium. She is now entirely free from lameness, nor has she the least pain in the knee even after severe walks; but there is evidently a rheumatic diathesis, and she now and then feels the grumbling pains of it on vicissitudes of weather, but not at the knee. Both Galvanic and Faradaic currents were employed, and she received some nine sittings in all, with medical treatment. (See p. 476, B.)

True neuralgia of the muscles may be known from the rheumatic affection of the muscles, because in the former the pains are very much more acute, and recur in frequent paroxysms; but there is not the dull ache or numb sensation in the interval of neuralgia that there is often in a rheumatism of the muscles. *After the pain ceases, if it is neuralgia, there is great weakness, or even partial palsy, of the muscle.* It may often be suspected as attending some insidious organic disease of the cord, or brain, as it does sometimes; and apoplexy or paralysis may, sooner or later, attack the patient. So, indeed, do I always suspect even neuralgic pains *that are chronic, which proceed from the cervical or the brachial plexus*, the recurring paroxysms involving the shoulder or upper arm. And this may prove more *generally* true of all severe and long recurring neuralgias,

especially those of muscles; particularly if they do not completely yield to correct electric treatments, provided always the habits of the patient will not account for them. As we are led to be suspicious of insidious lesions of, or formations in, the brain, from the ugly muscular neuralgias of the shoulder, so should the severe neuralgic pains of the muscles of the loins or thighs always put us on our guard, at least by a suspicion of the existence of softening or other organic lesions of the cord, or its membranes.

Neuralgia of the *skin* (true hyperæsthesia of the sentient nerves) is frequently noticed in connection with some eruption, as *herpes;* also in most hysterical cases. The sensation is exquisite sensitiveness to every touch, or intense prickling, or insufferable burning, or true pains in the skin. This is often alternated with numbness, &c. (See Appendix G, Note 5.)

A neuralgic affection of the *periosteum* of the bones, I am seriously led to believe, is more frequent than recognized. When observed, there is too ready a disposition to attribute it to mercury or to syphilis. True, it is very often, in part at least, rheumatic; but it is equally true, that the periosteum of the skull, teeth, and of the shafts of bones do present true, uncomplicated neuralgic pains. (See Appendix F, Note 1.)

Neuralgia may attack the *ganglionic* nerves, and hence most visceral neuralgias, with but few exceptions, may be referred to this medium. We find presenting in practice cases that properly come under this caption, that manifest pains mostly in the head, and constitute one large class of the *neuralgic headaches.* These are the plunging and bewildering head-pains, that now and then a patient of delicate constitution or of high nervous endowment or temperament has to suffer in regular or irregular and often recurring paroxysms, for years together. The attacks are usually intermitting; but I have had some patients who suffered for many years, with remissions it is true, but never entirely free from the pain. Light, heat, cold, mental or moral emotions, and the state of the stomach aggravate it, and at any time provoke to a paroxysm, the same as in any simple and true neuralgia. Is it, then, *an excessive exaltation of sensibility in the ganglionic*

or sympathetic nerves, or is it owing to *increased vascular determination to the head*,— or *owing to vascular turgescence from sluggish circulation* in the head? I am more inclined to believe it is *both* the former and the latter. In a word, I believe there is a class of ganglionic neuralgias. (See p. 417, and F, Note 2.)

In like manner, and for the same reasons, we may find cases presenting of neuralgia of the *heart*, as *angina pectoris*, and other forms of nervous heart-pains; neuralgia of the *stomach*, as gastralgia, or gastrodynia, and perhaps complicated with other morbid conditions; neuralgia even of the *liver*, called hepatalgia; of the *spleen*, and called by systematic writers *splenalgia;* neuralgia of the *duodenum*, *colon*, and *ileus*, called *nervous colic*, and more particularly *lead colic;* neuralgia of the *kidneys*, and of the *urinary bladder*, called *nephralgia*, &c. A neuralgic affection of the urinary organs is usually attended with *increased* secretion of urine, as, indeed, augmented secretion is characteristic of neuralgia of all secreting organs.

Neuralgia of the uterus is a fact; but these cases are more generally turned over to us as unmanageable cases of *uterine congestion*, or of *irritable uterus*. The cauterizing the cervix, the pessory support, the leeches, douches, and injections, fail to relieve or restore, but rather aggravate these cases, because they are in effect true irritants to this condition of the organ. Therefore, from among all the painful affections of the uterus, we must be careful to discriminate those that are truly and simply *neuralgic*. Now and then we find distressing cases of true neuralgia of the *vagina*. The patient more generally describes it as a most acute burning or scalding, or as a heavy plunging pain, occurring *often*, but not lasting long, and followed with a continued aching, throbbing, or soreness. There is usually found no lesion of the vulva, vagina, nor of the uterus. But we should recollect always, that this neuralgia may be, as it sometimes is, merely symptomatic of serious organic lesion of the womb. (E.)

Visceral neuralgia, being an affection of the *sympathetic system of nerves*, may therefore constitute the most severe and protracted bodily sufferings under which mortals can so long live. The source of sufferings, undefined, yet everlastingly com-

plained of, by the *hypochondriacal* and the *hysterical*, is doubtless seated here. Their case is very generally viewed either as mostly imagined, or else as remarkably exaggerated. This view of their case is taken, all the more, because their general health appears so good, or rather because it is so little impaired. But these, to them, abnormal sensations and indescribable sufferings, engaging the entire life attention of the patient, develop a persistent despondency or peculiarity, with a ceaseless apprehension. But to other persons, these complaints being viewed usually in the light or connection of very slight evidence or appearance of real ailment, often lead to a sincere belief in their want of reality; while, in fact, *they should be viewed*, as all needful evidence of a greatly impaired balance of action, in the great chain of ganglionic nerves. Dr. Copeland thinks it is a state of *asthenia* of this part of the nervous system, and that associated with a morbid exaltation (hyperæsthesia) of its physiological sensibility, which makes it a true neuralgia, and not unfrequently attended with some hidden functional or structural lesion of one or more important internal organ, and more particularly of the organs subservient to the perpetuation of organic life. (F, G.)

Infra-mammary Pain. — Dr. Coote, of London, says he has closely analyzed a series of some fifty cases of infra-mammary pain, and now finds it necessary to distinguish between *two kinds* of painful affections, to which the infra-mammary region is liable. The *first class*, he thinks, should be designated as "intercostal neuralgia," for it is liable to affect any region of the thoracic walls. The character of this pain is acute, plunging, paroxysmal. It is seated in one or more intercostal spaces, and mostly where the *cutaneous* branches of the nerves are most freely distributed, sometimes shooting around the chest, as if above the course of the nerve and its ramifications. Here there is superficial tenderness, or tenderness on pressure, or there is periodical pain. (See Appendix G.)

The *second class* of infra-mammary pain that Dr. Coote wishes to call our attention more particularly to, is a dull, aching pain, that is *seated*, being situated in one definite locality under the left breast, and extending generally over the seventh, eighth, and

ninth ribs, with the seventh and eighth intercostal spaces; never shooting along the nerve course, but rather darting deeply back *through* the chest to the back, or into the throat, in the former case seeming to give rise to the *inter-scapular pain;* in the latter, being associated with the hysterical globus. It is rarely tender on pressure, and it is not regularly periodical. He says, that uterine disorder does frequently accompany the true infra-mammary pain; but that it should be the cause of it, is impossible, for these two conditions cannot stand in relation to each other as cause and effect, as either does exist without the other. The infra-mammary pain is thought by some to be one of the most common symptoms of "incipient lateral curvature of the spine," and should always lead us to investigate the state of the spine, whenever we hear of this *ceaseless* though variable pain. But this, to my mind, has been exaggerated as to *frequency* of occurrence. These being facts, and for other weighty reasons, Dr. Coote infers that true infra-mammary pain is a mere *symptom* of a generally depressed or diminished state of the nervous endurance; and, secondly, that it is *one of a group* of symptoms intimately connected with the deranged vaso-motory system, and therefore with some vascular derangement.

The conclusions finally are, that true infra-mammary pain is simply a species of *peripheral neuralgia*, having, probably, its origin in mal-nutrition of the smaller nerves and blood vessels. The immediate cause of this kind of vascular derangement consists in disordered enervation of the smaller arteries of the whole body, occasioning irregular spasms and dilatation of their walls — a condition, which, while in the infra-mammary region it occasions neuralgia, in other parts gives rise to chills and flushes, to palpitation, to excessive or to defective secretion, to congestions, to hemorrhages, and to fluxes; while an analogous state of the nerves of the alimentary canal produces obstinate constipation. The cause of this extensively disordered state of the vaso-motory nerves is to be sought for in the more *general* conditions and habits of the patient. For obvious reasons, it is more likely to occur in women than in men, yet it does certainly also occur in men, as we often see.

If these views are correct, the indications for treatment are twofold. First, to arouse the vaso-motory nerves into at least temporary activity, so as to relieve special symptoms. Secondly, to give these permanent vigor, by improving the general innervation and nutrition of the whole body, and particularly of its surface. To this end employ electricity, food, air, and rest; to these the various tonic medicines are mere auxiliaries. (See Appendix F, G.)

Young women frequently suffer from *pains* about the mammary region, and the intercostal spaces. These respectively are very often mistaken for *pleuritis*, or something else besides what they truly are, because these very different pains, occurring in the same place, are not studied and distinguished. But if you seek access to the dorsal or cervical region, and press *gently* along the sides of the spinous processes of the vertebræ, but not on them, or else along the lower margin of the ribs, i. e., tracing the fingers along between the ribs, from the spine forwards, you will very quickly *awaken* the pain of neuralgia, which may be at the point of pressure, or it may be awakened at some little distance from it, but in the course of the nerve, or in its peripheric branches. If the peripheric branches that terminate in the integument are thus aroused, it is still *neuralgia;* but if the deeper terminal (motor) nerve branches, that are lost in the muscle fibres, are the seat of the pain, and are aroused not so, but rather by touching the surface any where over it, then we have *muscular hyperæsthesia*, which after all is probably only a neuralgia of the terminal twigs of true motor nerves. This will prove quite a sufficient test to satisfy that you have there either found one of Valleix's *painful spots*, and the pain is a fair neuralgia, or else is that other nerve manifestation that we call muscular hyperæsthesia, (and has been called also muscular rheumatism, or neuralgic rheumatism of the muscles,) but not a pain proceeding from an inflammatory action, (except it be about the nerves,) but certainly not in the pleura, nor in the viscera of the thorax. (See Appendix G.)

Spinal Irritation.—The views of Dr. Inman, of the Liverpool Royal Infirmary, should certainly receive our careful considera-

tion. He says the prevailing cause of these painful affections, termed "spinal irritation," in his judgment, is due to some morbid condition of the back muscles, rather than of the spinal nerves; and that the so-called "*spinal disorder*" originates more commonly in a feeble and painful affection of the muscles of the back. He says he has seen numerous cases in which these affections have been mistaken for symptoms of inflammation, and were treated by depletory measures, and rendered worse in consequence; in which Faradaizing, with a due amount of rest to the over-worked or strained muscles, with good diet, and other recuperating means, effected a speedy cure.

Passing from the painful affections of the muscles in general to those of the "spine" in particular, Dr. Inman considers that most of the cases of so-called spinal irritation are, after all, really owing to causes *originating* in the muscles, and that they ought to be treated generally by sustaining the general health, giving repose to the affected muscles, and assisting their action, when necessary, by quick and smart electric currents, by well-contrived artificial supports. The use of stays, therefore, *if not laced*, is not to be condemned as an article of female dress; *but when so used they are rather beneficial, by aiding the action of the muscles in preserving the equilibrium of the spinal column.* The reference of such cases to the general phenomena of hysteria is entirely unphilosophical. The views of Dr. Inman on the nature of *spinal* irritation, when summed up, are these: —

"I believe that the vast majority of the symptoms considered as the *result* of spinal irritation arises rather from over-exertion of one or more portions of the muscular system in the already debilitated subject; that the spinal tenderness of the spinous processes has a similar origin; and that the other symptoms considered as *resulting* from spinal tenderness are concomitants only, and are referable to the common cause." (See Notes F, G.)

Local Pulsation, occasionally noticed in the male, but far more frequently in the female, may be put down as "*local hysteria*," and arising from that peculiar state of the nervous system when hysteria may be manifested. This is a strong pulsation of the aorta in the epigastric region, *strongly simulating*

aneurism. But by observing the decidedly nervous, hypochondriacal, or hysterical state of the patient, we need feel no apprehension. As the nerves become toned, and the strength is improved, these symptoms will vanish. Hysterical spasmodic affections there are, among which are a curious class of maladies which often prove exceedingly troublesome, as aphonia, and croupy laryngeal affections, and likewise sobbing and sneezing.

Case. — Cornelia B., aged eighteen, came under treatment, complaining of severe pain in the dorsal region. She was a fleshy and stout-built girl, but looking in some sense delicate and unhealthy. Her business was that of a seamstress, and of late years she had run a stitching machine, in the employ of Hovey & Co. She reported that her pain and extreme weakness had existed for the last year previous, so as to quite disable her for work at times; particularly did this occur just before her catamenial periods; the pain occupying the middle of the back, and along the region of the spine, which was so extremely tender to the slightest touch or pressure, that any application of the hand to that portion of the back, even over the dress, would cause most disagreeable sensations, and if applied directly to the skin, bring on a turn of great suffering. When more closely examined, I found that this pain was confined to the fifth, sixth, seventh, and eighth dorsal vertebræ; for while on any other portion of the spine she would bear even forcible pressure, the least touch here caused her to scream with pain, so extreme was the sensitiveness of this portion of the back. But mark — if her attention was suddenly and strongly drawn off to some other distant object or subject, I could carefully and adroitly glide my hand from a sound region to this exquisitely tender region, and handle it roughly for that time without producing more effect there than elsewhere. This fairly diagnosticated the case as what is called *local hysteria* in the more common acceptation of that term.

Her treatment may be summed up thus: To have one *seance* daily, and at the same time to continue the medicine that she had been taking from her family physician, viz., *Griffith's myrrh*

mixture, with ammonia and valerian added, (which, by the way, is one of our very best preparations of iron for these cases.) The first few sittings occupied only three minutes each. *Circle treatment* was the principal method of operating, and this was done by placing one large and moist sponge electrode, which was the *positive*, over the painful part, while the other electrode was applied some ten inches from the first, and carried in a radius about it, but *without* removing either of them until through; using at first a very gentle and then a stronger Faradaic current, but if at hand, a galvanic current is better still. This was continued for one week. Said she was certainly one half better. To omit medicine and electric treatment now for one week; but to take in the mean time, twice a day, a pill of the sulphate of iron and quinine, and to apply to the dorsal spine a lotion of soap liniment and extract of opium, in equal parts, at bed time. Improvement continues; looks much better, and her gait is more natural and free. To repeat the electrical sittings and the myrrh mixture daily for a week more. The negative electrode was often carried as far as the cervical spine, the pit of the stomach, and over the bowels, the pelvis, lumbar and sacral regions. This quite chased away all pains; her appetite and rest are greatly improved. This case was dismissed with advice to shock the dorsal spine every evening with a towel squeezed out in very cold water, and applied suddenly, with a wipe up and down the whole back, which was then to be as quickly rubbed and dried, and the patient to be got into bed, well tucked in. She immediately resumed her former employment, and has regained very substantial health.

Pains about the Loins.—Dr. Oke says, most truly, that there is no symptom more commonly met with in the general practice of medicine than "pain in the loins." To arrive at its *true cause*, in any given case, we must try to ascertain what function is principally involved; we propose,—

1. If the pain be *rheumatic*, it (soreness) will be increased by pressure on the seat of pain; and still more, if it be neuralgic, if pressure be made over the origin of the nerves there distributed. If rheumatic, the pain will be increased by the slightest

action of the affected muscles. There will also be rheumatism or neuralgia in other parts of the body or limbs; the system will not be much disordered; the urine will be high colored, and deposit the lithates.

2. If from disease of the spinal column, the pain will be aggravated by percussion upon or along the sides of the spinous processes at this portion of the back, or by suddenly striking the toes against an uneven surface. There will be involuntary action of the muscles, especially of the flexors of the legs, diminished temperature, abnormal feelings, and more or less loss of power of the lower limbs. The spinous process of the affected vertebræ may possibly be projected, and this would confirm it.

3. If from a collection of matter in or about the psoas muscle, if *unconnected* with spinal disease, then the pain will be continuous, dull, and deep-seated; extending from the loins down the *psoas*, or in whatever direction the matter may have taken its course. The pain will be increased by flexion of the thigh, and there will be difficulty in walking; moreover, there will be marks of a strumous habit, and more or less symptoms of hectic fever.

4. If the "loin pain" originates in irregular *hepatic* function, then the pain will shoot upwards along the splanchnic nerves to the scapulæ; the alvine evacuations will show deficiency, alteration or excess of bile; the urine will have a bilious tinge, there will be a congestion of the hemorrhoidal veins, and the spirits will be depressed.

5. If the "loin pain" arises from deranged *duodenal* function, then it will be noticed that about three or four hours after a meal, the pain will be aggravated, shooting through towards the right side of the abdomen, and continuing more or less until the food has passed from the duodenum into the jejunum. If this be the case, dyspeptic symptoms will prevail, and there will be likely to be painful pustules breaking out about the face. This last symptom, however, is not uniform, though frequent.

6. If the "loin pain" is from the *kidneys*, it will shoot down the course of the spermatic nerves, towards the round ligaments

in the female, or towards the testis in the male, which will often be retracted by the action of the spermatic nerve upon the cremaster muscle; and there will be more or less irritation communicated to the mucous membrane of the bladder. Then the urine will deposit mucous, calculous matter, blood, pus, or albumen, or it may be otherwise morbid in its composition.

7. If the "loin pain" be from the *uterus*, then the pain will be greatly in the back, and arise either from *disordered function*, or from *disease* of the uterus. In the former case the pain will be more of a neuralgic character, and it will return in forcing paroxysms, extending all around the hips and hypogastric region; will often be attended with some hysteria, or with increased menstrual discharge. In the latter case, that is, if from organic disease, the pain will be *constant* and severe, extending along the anterior crural nerve half way down the thighs. There will probably be a thin, offensive discharge from the vagina. The countenance will be wan and sallow, exhibiting the wear and tear of organic lesion.

8. If the given "loin pain" proceeds from the *colon*, there will be constipation, or *inflation* along the course of the bowel, or the fecal discharges will be of small and perhaps flattened diameter, or there will be marked soreness of the intestine under pressure; especially is this found along its ascending or descending portions, and is attended occasionally with passage of mucus or shreds of lymph, much in the form of a yellow soft jelly or phlegm, but more frequently as wet bits of drab-colored ribbons, stretching along on the outside of the hardened alvine excretions. (See Appendix E, Notes 1, 3, and G, Note 4.)

The correct *diagnosis* of painful nervous affections of the hip is of the utmost importance, and yet is not always so easy. I will therefore sum up the different characteristics or peculiarities of six of the most distinct affections of the hip, that may here be confounded, or mistaken the one for the other, viz.: true *sciatica*, *neuralgia*, *coxalgia*, *rheumatica*, *disease of the spine*, and *disease of the pelvic bones*, among which we may reckon the *sacro-iliac disease*. According to Dr. Frank Hamilton, professor of surgery at the Buffalo Medical College, and Dr. John

Erichsen, professor of surgery at University College, we may keep our eye on the following peculiarities : —

1. *Sciatica* occurs usually in persons of middle or *advanced* life ; the seat of the pain being back and below the articulation, and extending down the back of the limb, and there being no elongation of the limb, will enable us to effect the diagnosis here.

2. *Neuralgia* occurs at all ages ; but the peculiar neuralgic pain, following the course of the nerves, or manifested over the ramification of certain superficial nerve branches, or the wide-spread and superficial pain and soreness, or the coexistence of the "hysterical joint" and hysterical temperament, the sex of the patient, and the absence of all actual local disease, is sufficient to make the case clear ; but in young females it may be most readily confounded with the ulcerative sacro-iliac disease. The obliquity of the pelvis which sometimes occurs in the simple neuralgia, and "hysteria of the hip," causing *apparent* elongation of the limb, is readily detected, and is diagnostic, for it is removed for the time while the patient lies upon her back.

3. *Coxalgia.* — Hip disease may occur at all times of life ; but we must look out for that variety of hip disease that commences in the *acetabulum*, and primarily involves the pelvic bones, and only secondarily implicates the great joint. In hip disease the patient suffers most if pressure is made deeply just back of and above the trochanter, in the hollow behind that osseous prominence, or where pressure is made against the anterior part of the hip joint through the *pectinalis* muscle, and also when made upward from the foot ; pressure of the head of the femur into the acetabulum, abduction and rotation outwards, aggravate to an unbearable degree the sufferings of the patient. Movements that influence the hip *joint* merely, as well as all other movements, produce the greatest pain just in the joint.

4. *Rheumatism* may occur at any stage of life and in either sex ; but there will usually be other marks of it either present or in the history of the past, and the characteristic rheumatic pains will distinctively diagnosticate this sort of hip affection.

5. *Spinal Disease*, but more particularly that form of it which arises from an accumulation of pus, — as, for instance,

where an abscess results from caries of the vertebræ, but the accumulation gravitating downward through the fascia, it may and often does occupy the same situation on the pelvis as that which is occupied by the collection of pus resulting from sacro-iliac disease; but then there is tenderness over the affected portion, or the vertebra projects, or the spinal column has lost its flexibility, and now moves stiffly as a whole.

6. *Disease of the pelvic bones*, and disease of the sacro-iliac articulation, may occur entirely separate or together. The former may commence at the *crista ilii*, the *tuber ischii*, or at the *acetabulum*, which latter is the more usual seat of this disease, and then the symptoms are like ordinary coxalgia. By thus merely calling the attention, by this concise rehearsal, of young medical gentlemen to the possibility of such conditions, I trust to prevent them from falling into any serious error while treating the less or more grave nervous affections of the hip and pelvis. But, in all faithfulness, I should have mentioned one other affection that may assimilate either or all of these diseases. I refer to *the hysterical affection of the hip joint.* But here you will be put upon your guard by the age and sex of the patient, by other manifestations of hysteria, and, more especially, by *the excessive superficial tenderness over the whole haunch, hip, and thigh, but no pain on strongly pressing the limb from the foot towards the pelvis;* besides, the hysteric-hip patient has not the worn aspect of those really diseased patients, where the cartilages are ulcerating, and thus causing the pain.

Neuralgic or "Hysterical Affections of the Joints."

This condition, surely, refers to the nerves, not to the vessels of the affected part. As we have general affections of the vascular system, as well as local, so we may have morbid conditions of the nervous system, either as general or local. There is a *local* affection of the nerves called the neuralgic state, as tic douloureux; and I believe there is a *general* affection of the nerves as manifested in nervousness and in hysteria. But in the *hysterical affections of joints* the nervous affection is both local

and general. The pain about such joints is excruciatingly severe, far beyond what attends ulceration; but it lasts as long, and only so long, as the mind dwells upon it, and it recurs as instantly and as often as the mind reverts to it. Divert the patient's mind powerfully to another affair, and it is remarkable how almost instantaneously the suffering will vanish. These cases of simulated disease may not always be pure, — that is, without some simultaneous change of structure; but, usually, there is no sign of local disease beyond a slight swelling of the joint, and the temperature of the joint and limb is rarely changed; but not always so by any means, as heat and swelling do, now and then, attend hysterical affections of the joints and neuralgic affections generally. Dr. Skey, of St. Bartholomew's Hospital, in speaking of this, says, "We have, perhaps, in the history of mankind, no manifestation of the intimate relation between mind and body more remarkable than this — the entire and almost sudden cessation of severe pain simply through the curative agency of a train of *healthy thoughts*." (See p. 570.)

We see, perhaps, a delicate girl suffering "very greatly" with pain in the *back*, or *hip*, or *knee*, as a mysterious *recent case;* or we see a "maiden lady," perhaps, within ten years of thirty, who has long suffered with precisely the same state as a chronic affection, — *an old case*. We are told that "the pain is dreadful" — in some cases so severe that the patient holds her body in some perpetually reclining posture, or her leg as constantly semi-flexed and immovable. In some cases, though the patient is unceasingly complaining, she still walks about, at least at times. The pain and the pseudo-joint malady are generally in the direct *inverse ratio* with other hysterical symptoms; for here the hysteria is concentrated, and the pain is increased about the menstrual period. In the earlier stages the worst and most frequent pain is referred to a spot about the *ligamentum patellæ*, which is often greatly aggravated by the merest touch, but especially if the skin and sub-cutaneous fat here situated be gently pinched up between the thumb and finger. The knee joint is more apt to be thus affected than any other, and that without local mischief adequate to account for its intensity.

The patient does not appear worn as one whose joint is ulcerating. So is the position of the patient and limb peculiar and well worthy of remark. When we see her at rest as she chooses, we find her lying slightly over towards the affected side, and the sick limb is averted so as to lie on its outer side, with the knee semi-flexed and some swollen. If we attempt to apply our hand to the knee, the girl will shrink and express suffering before the limb is even touched; and if we do touch it, or attempt to move it, she will plead or shriek and resist it instantly and most earnestly. Even the merest approximation of the hand intimating the slightest indication of a manipulative examination, is met by the instantaneous extension of both her hands, and her whole attitude and expression are those of intense fear with resistance. Such is a hysterical joint, and such cases are by no means rare. (See Appendix F, G.)

Miss S., aged about thirty, was very sick before ten years of age, with severe cutaneous disease and fever, after which she began to feel at times a "stiffness" in the left hip joint, which was more marked from thirteen to fifteen, while at boarding school. She suffered great pain about that hip at menstrual times, and often for whole months together, when she became confined to her bed, and retained the limb in a semi-flexed position for long periods. She had had various and the best of medical advice and treatments for the last twenty years. When I saw her lying in bed, she was inclined somewhat over towards the affected hip, the limb drawn up, with the knee resting on a pillow, and the leg contracted upon the thigh. By measurement, (which was done only after most cautious, repeated, and deliberate manipulation of the ankle first, then gliding the hands along up to the knee, and while the fingers of one hand were carefully searching the contracted tendons back of the bend of the knee, and at the same time closely catechising the patient as regards sensations *there*, the other hand was glided over the hitherto *touch-me-not* hip joint, and before she was aware of it my fingers were deeply pressed, exploring the sound, deep-lying muscles about the long-fixed pseudo-anchylosed joint,) — I say that by actual measurement, it was found that the

femur was about three inches shorter than the other, and the leg on that side, from the under edge of the patella to the heel, was four inches shorter than its fellow, showing that the limb had not grown in proportion with the general development of this otherwise beautiful girl. Besides, the limb below the knee was atrophied, cold, and lifeless, while the thigh muscles were remarkably well developed, and the hip muscles were drawn together, tilting the pelvis, and largely projecting the whole hip. By any experienced and skilful eye this would be at once recognized as mainly a "hysteric-hip joint." There was no sign of local disease in progress, beyond a general swelling or enlargement of the whole hip. *Pain* — pain, not the concomitant of inflammation or ulceration, but pain *per se* — seems here to constitute the disease. These cases are said to possess, in one sense, a quality of *un*reality ; but it is not to be for one moment supposed that all these patients willingly deceive their medical attendant and best friends, nor that the pain complained of so long and incessantly has no real existence. If so, why does she not complain when pressure is made gradually but firmly from the foot towards the pelvis, which would be likely to give pain in almost every other hip joint or pelvis malady ? *

In fact, or effect, this disease may be *originally* produced by the peculiar circumstances and conditions of woman's life ; but I believe it soon becomes a *disease of habit*, or a true neurosis, and now more or less independent of uterine action or inaction ; but is rather become the peculiar contingency of the uncontrolled emotional feelings and morbid imaginations of the patient. Dr. Barwell says great harm is done by prescribing the indiscriminate and long use of steel, ethers, aloes, &c., for these patients. If this view be correct, the treatment should be general as well as *local*, and directed to the cerebral condition that produces this manifestation of pain, and to that faculty of *Will*, that sways the disease by its own or the emotional state. To control the emotions and will, is to cure the disease. Hence a plain, coarse, and *low diet*, *with plenty of regular exercise* for both body and mind, will be best calculated to break up this morbid habit and state. Let the patient have mainly plain, light, crusty

* See Dr. Walter Channing's work on the "*Bed Case*."

bread, of wheat or rye, cold, and at least one day old, with good butter, moderate tea, and meat, with potatoes or beans once a day. She must not sleep upon a feather bed, nor yet in a heated room; is to wear flannel, and over the affected joint and limb flannels of double thickness; to apply close over the painful joint at bed time a piece of oiled silk or rubber cloth, upon the under side of which is spread a drachm or two of opium that has been rubbed up very soft in a few drops of rum and hot water; to *shock* the spine by suddenly applying at every bed time a large towel squeezed out in very cold water, which is quickly passed a few times up and down the whole spine and back, and then is to be as quickly wiped dry and got into bed for the night.

Miss S. was positively encouraged that she should be benefited, and the electric treatments were commenced, with the regimen as above. As the pelvis had been tilted over for about twenty years, assimilating and exaggerating the position assumed in true hip disease, there was double curvature of the spine from the unequal action of the muscles of the back; besides, the left glutei could be felt in strong irritative, wavy contractions, and the nates, instead of being on that side as on the sound side, was very protuberant; therefore the first business was to balance up the action of the muscles of the back and loins. The first week was devoted to this, using the primary current of galvanism. Next, the *circle treatment* was instituted over the great sciatic nerve, just as employed in sciatica or neuralgia, observing the same rules and precautions.

In three months, this lady went to church regularly, and took her daily promenade in the Mall. The atrophy and coldness below the knee was replaced with more habitual warmth, flesh color, and plumpness; the contraction of the hamstrings so much overcome that a yardstick laid upon the knee pan would touch the upper end of the rectus femoris, while the lower end of the stick would rest upon the front of the ankle above the instep. Instead of the toes now pointing to the ground, she wore a steel spring high shoe, with her little foot nearly level, and she often walks without a cane, or even a perceptible limp.

During the past fall, however, the general health of this patient had run down, and the old hip affection had become the most prominent symptom. She was again treated, but, I regret to say, with not, as yet, so flattering success; but that she will recover ultimately, and be restored to health, usefulness, and happiness, I have not a doubt.

Headaches.

When tracing the cause of headaches, what do we learn from anatomical considerations, as to the probable *source* of pain *within* the cranium when a person is the subject of a true and profound headache? The *source* of distress, says Dr. Symonds, does not appear to be in the nervous matter, vesicular or tubular, either in that of the cerebral hemispheres or of the cerebellum. No evidence of *feeling* has ever been obtained by vivi-sectors, till they approach the sensory ganglia — the *thalami optici* and the *corpora quadrigemina*. But these, on the contrary, *are the centres of sensation* to all parts of the body, as well as to the head. All analogy points to some certain nerves as the source or medium of the pain. Numerous as are the nerves that come out of the cranium, there are to ocular view but very few that go into it. A branch of the *sub-occipital* accompanies the vertebral artery; but a *large majority* of the other nerves, destined for intra-cranial purposes, are derived from the *sympathetic*. *These*, then, we may feel satisfied, *are the nerves* which are of the chiefest interest to our present inquiry. Nerves of this class, we know, accompany blood vessels; and when we observe the large amount of these vessels, — as the brain and its membranes are more liberally supplied with blood than any other organ, the quantity being computed as one fifth of the blood of the whole body, — we might here, without searching farther, realize the enormous amount of minute network of ganglionic nerves. By the microscopic examinations of modern anatomists, in fact, they are traced in the greatest abundance.

There is also found a vast interlacement of nerves at the

base of the brain, derived from the plexuses of the vertebral, the basilar, and the carotid arteries, mingled with nerve threads connecting with the third, fourth, fifth, and the sixth pairs of cranial nerves, besides branches in the cavernous plexus, derived from some of the upper cervical nerves, as well as those connected with the pituitary body, otherwise called the *cephalic ganglion*. Now the nerves proceeding from this network, and accompanying the arteries of the brain, must possess the mixed endowment of their several sources. But then, whether or not the sensory properties of ganglionic, otherwise called sympathetic nerves, are entirely dependent on the cerebro-spinal fibres contained in them, (as Valentin believes,) or whether they arise from the gray fibres which *become* sensitive when altered by disease, (as Volkman believes,) is still a question. It is enough for us to know that the compound nerves of this sort seem to be capable of fulfilling almost every conceivable function of a nerve.

Whatever these peculiar nerves may effect on the chemical processes of the molecular laboratory of ultimate tissue, — whatever regulation they give to the blood vessels, — it can scarcely be doubted, says Dr. Symonds, that in many parts of the body they actually send messages of pain, if not of pleasure, to the sensorium; and that *they* are the telegraph lines that transmit influences from the seat of *emotion* to the parts where they are distributed, and perhaps have a reflex function also. They only seem not to attempt to convey motor impulses from the will. That our general sense of well-being must derive its favorable tidings from the various viscera, through these "union" telegraphers, can hardly be doubted; and certainly there is no other channel through which flow the miseries and anguish of the very many visceral disorders.

Seeing, then, that the ganglionic (sympathetic) nerves, so abundantly distributed through the brain and its membranes, *are largely implicated in profound headaches*, our next inquiry is turned to find the agencies which so act upon or through them as to cause painful feelings. Some of these are, obviously, local changes in the cerebral structure, as from sluggish circula-

tion, injuries, inflammation, or organic disease. There are also changes in the blood itself; and there are also disordered states of the nerves themselves, resulting often from functional causes, as in prolonged or excessive mental exertion, emotional excitement, &c. Other causes there are that act by sympathy, as through the nerves of special sensation; for instance, vivid light, or loud noises. There are also very familiar examples of *head pains* from impressions made on the branches of the fifth pair, as well as on the gastric, and on the intestinal, or genital nerves. Now, the stomach and the liver are always blamed for these profound headaches, and doubtless they are often guilty; but I believe that a too great, or otherwise bad impression made *at any one point*, — as on the eye, in the head, or stomach, — will involve the whole in a paroxysm of derangement and pain. If this is made in the brain, the stomach will as certainly be deranged, and the tongue foul, the bowels will tardily throw off scybalæ with mucus, etc., as if *vice versa*. This is a case of *hyperæsthesia of the ganglionic nerves*, and more particularly of that portion within the cranium. (See p. 401, and Appendix D, F.)

Headaches and pains in the head, then, may have either a diffused peripheral site on the scalp, as in persons of high neurotic temperament, or the pains may follow the course of the supra-orbital nerve, or the temporal branches of the *portio dura*, or the branches of the sub-occipital, and it will show its character either as hemicranial, or as "*clavus hystericus*," or as simple *neuralgia*; or the pain may have a *periosteal* seat, as in the rheumatic, or syphilitic; while here we are examining, as I believe, true *inter*-cranial headaches, arising possibly from molecular alteration of the nerve substance of the brain. But I am most strongly inclined to consider the elaborate moss-like network of intercranial *vascular nerve filaments* of the sympathetic to be in almost, if not all, true *profound headaches*, the very focus and medium of communication to the sensorium. These are ganglionic nerves, as we have just shown, and attend every capillary and fringe of minute ultimate artery.

Now, we know that periods, and *habits of successions* of

various sorts are the very nature of our nerves. They respond to, and learn to call for, habits — good regular habits; so will they soon learn to repeat, and even *demand*, evil habits, and painful periods, *as if natural.* Indeed, *the periodic evolution of nerve force is a law of our very nature;* and as this is true in physiology, so do we often see its force in neurological pathology, (morbid physiology?)

Headache! — for years, perhaps, a profound and often-recurring distress *in* the very dome of the great nerve centre, where all the influences and sympathies of the entire organism and being conspire to awake it anew, and perpetuate its existence! How shall we cure it? What actual change is to be brought about, *what new impression is to be established*, in this capital of states, this kingdom, with living automatic telegraphs with way-stations for simultaneously and harmoniously operating hydraulics, pneumatics, manufactories, and laboratories, where are large classes of operatives, individuals, families, and neighborhoods, each of which having offices, rights, and sympathies to be performed and sustained, represented and defended — yes, and are there not some peculiarly odd, sensitive, tattling, "mischief-making" ones? All this in one body! How shall we, then, relieve or cure a *profound headache?*

Now, my answer to all this is, first, simply, that *there is no one remedy — there can be no "specific"* for these cases. My rule of action here is, to stop the pain as soon as possible, and then prevent the recurrence by any and every possible means. Find out what causes the headache, and with greatest vigilance *avoid* this source. When the attack actually comes on, even unasked, then cut it short by any means at hand; *but cut it short*, break up the habit, break up any regular recurrence of paroxysm. One patient will find relief in standing up, another in lying down flat upon the back, another from opiates, but others only from stimulants; others get marked relief from a cup of hot tea or coffee, or perhaps these combined with morphia, or camphor, or brandy; while others find it better from a cold drink of boneset, (thoroughwort — *eupatorium perfoliatum;*) others there are who get relief from eating something, while a greater num-

ber are relieved by vomiting. But a sudden and *new mental diversion* will more surely *relieve it* than all the foregoing; and electric currents, applied according to the rules to be observed in other hyperæsthesia, will relieve *obstinate headaches* more uniformly, and that with a *curative tendency*, than all other known means together; but to this end the case needs to be studied, and the treatment must necessarily be more or less continued.

In treating inveterate headaches, I more usually employ the primary current of galvanism than the secondary current of electro-magnetism, although this latter can, for it does, succeed in very many cases. But I must here confess there is no small difficulty in giving directions how to decide, in a given case, without trial, as to which of these currents is best adapted to be successful. Moreover, I here recognize the *law*, that must be observed in the treatment of all painful nervous affections, and that is, that a larger class is benefited by the *direct* current, while a smaller class is only reached with a truly remedial effect by the *inverse* current. For instance, for one patient I apply one large and soft electrode to the base of the occiput, or a little lower, while the other is at the stomach, or down the lumbar region, so as to embrace the posterior cervical ganglia; then a *down-running* current of bearable strength, — say one eighth strength of electro-magnetic current, — or a stream of ten Daniell's or twenty Garratt's elements, (*without being reversed*,) for thirty seconds; then a recess of ten seconds; and then applied again in the same direction once, twice, or even seven times, if the head pain does not *begin* to yield. In another case, if such a *seance* is managed with a *down-running* current, it will succeed all the better. Generally speaking, the fair, the fleshy, and the hysterical simply require the down-running current, and that very light, and a short seance; while the lean, or the hardy, the cold in temperature, and the melancholic in temperament, seem to require the spring of the reflex action from an up-running current, whatever the battery or apparatus employed to give it. Where we are thwarted in the desired results, the electrodes may be positioned so as to run the current from the nape of the

neck to the pit of the stomach, or *umbilicus;* or from the nape of the neck to the dorsal spine, or even as low down as to the sacrum, and thus maintain the current, *down-running*, i. e., direct, by part-minute stages, but always in one direction, whatever that is, when once chosen, and we obtain good results. Indeed such a procedure cannot be systematically adopted without some positively sensible results; and even if the headache seems to be awakened to more severity by a given current direction, the work is then half done, for you have obtained a diagnostic test that now guides you in the future, and you will be — you must be — successful in breaking up all merely functional, habitual, or periodical headaches, where there is no organic disease, nor any habit persisted in that as constantly perpetuates the malady.

Treatment of Neuralgia. — All forms of neuralgia are obstinate of cure, or, more properly speaking, are *relapsing;* the many cases of which, taken in a strict sense, are not diseases in themselves, but appear either as the *herald* or *sequel* of some other disease or derangement, and often of a very slight derangement. But sometimes, even after the cause is removed, still the neuralgic pains recur, apparently from some abiding changed condition of the nerve, induced at first, as we have said, by some other disease or derangement of functions. But if the neuralgia is caused by wounds of the nerves, by inflammation, by hypertrophy, or by scirrhus of the neurilemma, or from disease of the great nerve centres, or from caries or exostosis of the bony passage through which the nerve passes, then it cannot be expected of any local electric treatments to cure the affection; nor indeed if it arises from any organic disease or *existing morbid states* of the liver, stomach, kidneys, uterus, or ovaries, &c.; nor yet if the affection is continued from repeated exposure to damp or cold, or from exhausting and irregular indulgences, or from over-working habits. But if the neuralgia arose even from some such cause, *which is now removed*, and the affection is merely *a morbid exaltation of sensibility*, without structural change or faulty function acting as an exciting cause, or if it is of a rheumatic origin, or of no assignable foreign or

vicarious origin whatever, then can Faradaic or Galvanic electricity have a truly curative effect, and that by changing and thus permanently restoring the nervo-electric polarity of the deranged nerves. (See pp. 380, 475, and Appendix D, E, G.)

The excruciating pains of neuralgia are easily distinguished from those of rheumatism, mainly by the former following the course of the nerves, or from their being fixed at the point of exit of a large nerve trunk from the bones, as the facial, trifacial, and sciatic nerves are examples. Some neuralgias, we have said, are evidently complicated with rheumatism; and they must receive a modified treatment, according as either of these characteristics predominates. The most grave and indeed frequent form of this is the sciatic neuralgic rheumatism; and these attacks are often occasioned by inter-pelvic causes, as well as from exposure to cold or damp immediately *after fatigue.* With an eye, then, on the origin of the affection, shape the plan for eradicating it; if this is not possible, then aim for toning it down to some more bearable kind or degree.

For these, as, indeed, for all cases of neuralgia, choose the largest sized and softest sponge electrodes; place one — the positive pole, for example — over the exit of the sciatic nerve; i. e., just back of the most prominent bone on the outside of the hip and thigh, which is the *trochanter major*, in the hollow between it and the *ischium* bone, which spot is easily found from its being the seat of exquisite tenderness or pain; while the other sponge electrode is firmly applied on the terminal twigs, along down the foot, and there retained with a steady down-running (direct) current of electro-magnetism, or galvanism, *of bearable strength, for one minute;* then very carefully remove, or glide along the positive electrode some six inches down the limb for a half minute more, and then again, and again, in such short stages, until arriving at the ankle; in all some five or six minutes. The electrodes must be applied with the greatest possible gentleness, and removed equally so. Care must be taken not to touch the limb with any kind of shock, or reversed current, *not even for an instant.* The electrodes may be applied, skating along down the limb first one, every minute, and then the other,

but always in the same order and at short moves. The lower — that is, the negative — electrode should never be placed above any painful neuralgic spot, but always aim to include between the two electrodes the painful nerve trunk, as well as the painful periphery. When the whole nervous system appears to be more or less implicated in the neuralgic or hyperæsthetic state, I then apply the positive electrode rather to the nape of the neck, at first, and then, by skating-like motions, from minute to minute, gently work it along down the back, not only over the spinous processes, but again on the muscles of the sides of the back, while the lower sponge is planted below all painful localities. I say, glide the positive sponge in stages gently along down the back, more slowly over the *cauda equina*, and so along over the hip or the crest of the ilium, and down the lower limb, tracing along the painful track. Let the seance last as long as the pain continues, i. e., never quit while pain or even soreness remains. If the pain returns within six hours, repeat the seance at once; but if merely some pain lingers here and there in after hours, then daily applications will suffice. If a moderate current is first used, and does not succeed, then bring a stronger one to bear upon the case. If this has been fairly tried, and, perhaps, faithfully repeated, and yet without success, then I change the mode of proceeding by applying the electrodes reversed, i. e., with an up-running current, *embracing only the nerve trunk* of the affected part. But these are rare cases. Where the neuralgic-like pain is seated, and proves obstinate, the *circle treatments*, daily repeated, will eradicate the last vestige.

We notice that M. Magendie was the first fairly to employ the primary, continuous galvanic current in the treatment of neuralgias. When the pain was in the face, for instance, he employed two *acu-puncture needles* to convey the current, the one from the positive pole inserted in the very spot where the painful nerve makes its exit from the bone, while the other needle was inserted into the substance of the muscles that receive the twigs of that nerve. The negative needle was removed and then reinserted every few minutes wherever pain was felt, until all the pains were fairly chased away. But this was not always effected per-

manently until after several sittings. The needles were allowed to remain inserted for a little time, during which the patient was directed to make such motions as had usually before brought on the paroxysms of pain, and if any was still found to be produced, the current was repeated. This he termed "*electro-puncture*." But in other parts of the body he often used the sponge electrodes. By carrying out the rules and conditions already obtained by Nobili and Marianini, he restricted the use of the galvanic current to a *bearable strength*, and, in given cases, to *certain given current directions* as regards the affected nerves.

In all cases of pure neuralgia he always employed the positive pole of the battery towards or nearest to the nerve centre and over the nerve trunk, while the negative pole is placed over, or into, some portion of the ramifications of that nerve; so that the electric stream is *direct, when treating neuralgias.* But he held, also, that in case the current was employed in the opposite direction, and, if not too severely employed, the therapeutic effect would still more or less take place, it being in that case a *disturbing method*, which is, indeed, a very law in therapeutics; but then there would be a waste of remedial power, and a production of needless pain.

M. Becquerel advises to the employment of this powerful agent in the most gentle and agreeable manner possible, and for that reason he thinks it best to dispense with the needles, and employ moist sponges, using sometimes the secondary or Faradaic, and at others the primary or Galvanic currents.

Dr. James, a recent English author, gives it as his experience, that one, and the largest, class of neuralgic patients is best treated by the veritable, primary, and continuous galvanic current, of only moderate intensity; but he does not define the class, or say particularly how he directed the current.

It is my own experience that the neuralgias met with, in this country, are mostly of two quite distinct kinds, — or, at least so they may be termed, — as relates to the successful adaptation of the different electric currents. If the operator cannot by tact or discrimination distinguish these at first, he will find that

on applying the continuous galvanic current he will succeed admirably in some cases, but, perhaps, fail as signally in others; and not only so, but speedily aggravate the case. Now, if in this dilemma, he but just reverses the direction of the current and tries again, in a very few *seances* he will find his triumph, and that in the very same case where before he failed. And electro-magnetism may also be introduced in the place of galvanism with happy results, often, almost, if not quite, equal to the former, provided the same rules are observed as regards the direction of the current, and, at the same time, avoiding shocks and perturbations.

Whenever we find by proving, and have decided upon using a given direction of current in a case of neuralgia, this relative position of the two sponge electrodes, during all that *seance*, is to be strictly observed — i. e., for neuralgias; for one instant of a sudden and actually reversed current can get up an increased susceptibility that is rarely calmed again in that *seance*. My own practice is not to exceed ten minutes, in all, at any one sitting, and more frequently only five or six minutes, using a gentle current, and large, soft electrodes. The time of the whole sitting may be a half hour, or more if desirable; but the time I refer to particularly relates to the length of time the current traverses the nerves, or, rather, is applied to the skin. In case Faradaic currents are used, (i. e., electro-magnetism,) double the time may be profitably devoted to each sitting. Then, if the clearing out of the neuralgic pains is not effected by some half a dozen or dozen *seances*, it will be found that the pains are the result of inflammation, or but *symptomatic* of some existing morbid function that first needs to be set right, or of some more serious, and, perhaps, remote organic disease that is incurable.

I would only add here, as electro-magnetic machines are the more generally owned, and for other reasons, also, are more likely to be employed in these cases, that first class and fine coil instruments only should be relied upon. If the vibrations are coarse or irregular, and cannot be nicely graduated to a rapid, even, and fine current, that nearly resembles the true primary galvanic current, then I should never touch a neuralgic patient

with it. Success in these cases greatly depends on a smooth current with gentleness: the applying, the continuing, and removing the current without change of *density*, or change of *direction* of the current, in the main *is the rule here for treatment*. (See p. 477, and Appendix B.)

In muscular and periphery neuralgia, as, indeed, in some other cases where the pains are more *diffused* and somewhat rheumatic, we can manage to observe this *law of application* for neuralgia, and yet, as it were, wash or bathe the part with the electric current. By beginning with a very gentle current of electro-magnetism, then after a few seconds or a minute, (and while the applied sponges are being very gently moved along over the skin,) let another person push the bundle of wires or iron rod a little further into the machine, to increase the current in the most cautious and imperceptible manner possible, and the patient will bear this *labile* movement of the electrode, and with it a larger current than could be borne if abruptly applied, or retained in one position when applied.

After no small experience in treating the various neuralgias by means of electricity, Dr. H. W. Lobb says he is now inclined to divide the whole family of neuralgias (as respects treatment by this means) into *two great divisions* or classes; the one requiring the "*direct*" current of Galvanism or Faradaism to effect a cure, while the other class is reached only by the "*inverse*" current. In this connection, he calls the direct current *stimulating*, and the inverse current *lowering*, *calming*, or depressing in its effects on such morbid nerve action. Therefore, he says, the sagacity of the physician must decide in a given case which current is best — is the right and only one to be used. He remarks further, that "during the month of June last, I had under my treatment, at the Western General Dispensatory, three cases of infra-mammary pain that was neuralgic. Dr. C. was present, and also desirous of making use of the so-called continuous (primary) current of galvanism, as a means of diagnosis and treatment, he having heard that I believed neuralgias to be, in this respect, of two distinct classes. Therefore, the *direct current* was applied to two of these women, and

that with very decided and immediate relief. To the third case, the *inverse current*, being indicated, was applied, which, in one minute, not only removed the pain, but consciousness also; in which state she remained for some ten or fifteen minutes. Upon restoration, she said that her side was quite numb. This was an instance not only of local but of general anæsthesia, produced, by the aid of the continuous current of electricity, in less than one minute."

It is to be regretted that, in so interesting a matter, the number and size of the elements, and kind of battery power employed, were not mentioned. But doubtless this was a very nervous or peculiarly impressible case, and gave not the ordinarily to be expected result of galvanic electricity, unless employed in just such cases, or else there is an outrageous battery strength brought to bear, that is entirely disproportionate to the nerve endurance of the patient, and hence dangerous. It is my own opinion, judging from the sketch of the case, that a too strong or too long-continued current was employed for the constitution or *condition* of that particular case; that is, the same current might have been borne for fifteen or twenty seconds, and even accomplished the purpose and no more, that so affected her in fifty; or half that current could have been borne the whole fifty seconds, with only good results.

Another very curious example of anæsthesia produced by the primary current, and *local* in this instance, is thus reported by Dr. Coot, of Liverpool: "A young lady, paralyzed in her right arm since her third year of age, was wearing a local galvanic arrangement for the generation of the continuous current, to excite the circulation, during the intermittences of the regular application of the interrupted current, which was being done to arouse the paralyzed muscles. One day she complained that the arm was colder than before she wore the local battery; and, in fact, on examination, it was found more like a piece of marble, and perfectly without sensation! Upon further investigation, I found that she had, upon exciting anew the chain, returned it to the arm wrong, i. e., so that an *inverse* current passed instead of a direct, thus producing anæsthesia. I was convinced from this,

that anæsthesia might be produced by the inverse continuous current of electricity, *if of sufficient tension to pass along the nerve we are desirous of depriving of sensation.*"

But, again, as to the *two* classes of all kinds of the neuralgic for electric treatments. This interests me much, for it accords with my own experience. No doubt this affection may be set up in an organism under quite different circumstances, as in *astenia* as well as in *hyperamea*, and, indeed, in opposite conditions of the nerves, or body, in many other respects; therefore it is not strange that a different change of nerve polarity should be required for the restoration. The careful and correct application of the current itself in a given way, is the best diagnosis, for it will speedily restore or aggravate. In the latter case, change the *direction* of the current, and you triumph. Should you fail now again, you may judge that there is exposure, bad habit, functional derangement, inflammation, or organic disease.

Case 1. — An elderly clergyman, who had long been very subject to sciatica, of a truly neuralgic kind, having heard of my mode of treating such cases by galvano-puncture, came from a distant part of the state, last spring, for the purpose of putting himself under my care, and remaining in the city until cured. I inserted six of the four-inch gold needles, as three pairs, along the course of the great nerve trunk of the right thigh, every other day, for three times. In one week he was so well that he concluded to return home. He writes me that he has been quite well of it ever since. This was a chronic case.

Case 2. — A lady in the prime of life, residing in Dorchester, but a patient of Dr. Bartlett, of Roxbury, about forty years of age, was suffering so much from lumbago and sciatica on both sides, that she was almost helpless; and being fleshy, she could not get in or out of bed, nor even arise from her invalid chair, without assistance. She had long tried internal medicines, blisters, tincture of iodine, mustard, and cold water. I was sent for by the advice of her physician, and applied (or rather inserted) the long gold needles for electro-puncture, over the most painful parts, and used in this case a very mild primary direct current, but held steadily in contact with the silver wires in the eye of

the needles, for one minute; that is, there were inserted three pairs of needles, and I made contact with two at a time, and thus occupied at each sitting some five or six minutes in all. In ten days this was repeated five times, when she walked down stairs and about the dining room, as she had not done since the winter before. She soon recovered, and is still well, and may be seen every fair day in her carriage about our streets where ladies do trading.

Case 3. — A truckman, of middle age, applied, with a chronic neuralgic rheumatism lurking about the parts of the right shoulder, but mostly in the deltoid muscle, at its lower end where it is inserted in the humerus. The shoulder muscles and joint were so lame and painful, that he could not raise his arm, and the pains at times were most excruciating. It appeared to me a case to be most speedily benefited by electro-puncture, and I therefore inserted one needle in front and below the head of the humerus, and the other at the insertion of the deltoid, and with an *inverse* current of bearable strength, which was five Daniell's batteries; it was allowed to continue for some five minutes, with as many interruptions at every thirty seconds. He was greatly "suppled" by this one *seance*, and two more eradicated the whole "*tangle*," as he termed it, so that he swung his arm in all directions; only it was not as strong, however, as before the rheumatic attack, which was some months previous.

It can be seen, I think, that some chronic rheumatisms and chronic neuralgias may thus be cut short more surely than by any other means. No doubt simple *acu-puncture* would prove serviceable in these same selected cases; but it is my opinion, from experience with both, that every *seance* with electro-puncture strikes a more effectual blow for disturbing, or for modifying by direct catalysis, and hence changing the polarity of the morbid nerves, and therefore for eradicating the disease, than *many* acu-punctures, or blisters, or other less disturbing forces can possibly do.

In one extremely bad case of sciatica, I adopted the following plan: The patient was placed on the operating mattress, lying on his sound side, with the limb semi-flexed; placed the posi-

tive electrode, which was a soft sponge, over the most painful spot, and this was just back of the trochanter major; while the negative electrode, also a moist sponge, was firmly placed some four or five inches off, and then at every ten seconds moved along in a radius about the first electrode, so that the current of medium strength, whether Galvanic or Faradaic, should flow in all directions *from* that centre of pain, but not removing the electrode until the pain was fairly subdued, which, however, was brought about in some six minutes. The *seance* was then finished with the steady current run *down* the limb for a minute or two from hip to ankle. When twinges of pain occurred during the *seance*, I at once took off the *upper* electrode, some two or three times, very suddenly, so as to produce twitchings of the muscles, and this scattered the new-growing pains. This treatment was repeated every other day for ten days, when all pains had vanished completely. Further treatment, but more seldom, restored the limb also from weakness and lameness, so as to be very nearly, if not quite, equal to the other.

Reading the practice of M. Ducros, from the *Gazette Medicale*, we find he says, "In the most intense hemicrania, and in the most obstinate *tic doulourenx*, whether fronto-facial or temporo-facial, the pain disappears *instantly* upon the application of extra strong aqua ammonia to the palatine arch, by means of a camel's hair brush; the brush being allowed to remain on the part till a copious flow of tears has been excited. If the pain returns, a fresh application will again produce a cessation of the neuralgia." I determined, for the same end, to direct a small buckskin-covered ball electrode to the same part, while the other electrode was planted upon the nape of the neck, in a most violent case I had, and to my surprise and the patient's relief and gratification, the excessive pain would cease upon a few seconds' administration of strong direct electro-magnetism, or a direct current shock, or two, from some twenty cups of galvanism. The pain did not return so soon, nor so powerfully, as at first, but it did return in some degree after each such temporary victory. But by repeating the application a few times, all pain and soreness were eradicated.

It is observed, that where arsenic is resorted to, as aid in the treatment of some obstinate neuralgias, its *curative* effects operate uniformly most favorably on persons who are of lax fibre, and have a languid state of the circulation, whose secretions are rather profuse, urine is pale and plentiful, and whose skin is moist and cold. In such persons, it not only aids in the relief of the neuralgic pains, but it actually improves the general

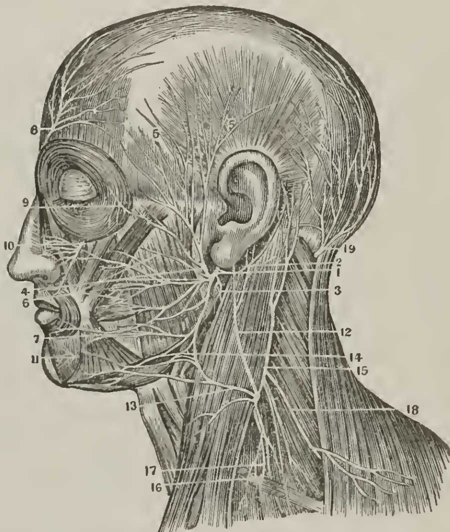


Fig. 68. A View of the Facial Nerve, together with the branches of the Cervical Plexus.

1. The Facial Nerve or Portia Dura, escaping from the Stylo-Mastoid Foramen. The Parotid Gland has been removed to show this.
2. The Posterior Auricular Branch of the Facial.
3. The Stylo-Hyoid Branch.
4. The Pes Anserinus.
5. Temporal Branches of the Facial Nerve.
6. Malar Branches.
7. Cervico-Facial Branches.
8. Supra-Orbital Nerve.
9. Sub-Cutaneous Malæ, a branch of the Superior Maxillary.
10. The Infra-Orbital Nerve, or second branch of the Fifth Pair.
11. Terminal Branches of the Inferior Dental Nerve, called Mental.
12. Nervus Auricularius of the Cervical Plexus.
13. The Superficialis Colli Nerve.
14. The Plexus formed by the last-named nerve and the branches of the Facial.
15. Occipitalis Minor Branch of the Cervical Plexus.
16. Descending Branches of the Cervical Plexus.
17. The *Phrenic Nerve.*
18. The Nervus Accessorius of the Eighth Pair.
19. The Great or Posterior Occipital Nerve.

health, and gives more firmness and vigor to the constitution, and *power of endurance to the nervous system.* At least, so it operates if taken while under repeated treatments by electricity. Astonishing improvement have I seen, now and then, in such, and by such means, as if the constitution were made anew. But (mark!) where the tongue is coated, or is red at its tip or edges, or where the urine is of a deep-red color, or is decidedly scantily secreted, or frequently deposits the heavy lithates of ammonia, then arsenic is not a good auxiliary, but will both fail *and do harm* by aggravating the existing gastric derangement and pains. Correct the stomach thoroughly first, and often it can then do good service in the very same case. During the administration of arsenic, the patient should strictly avoid the use of fruits, and all acids, as well as confectionery; but the occasional application of electric currents enhances its alterative and curative effects.

Superficial Nerves in the Facial Neuralgic Region.

I wish now to pass in short review the exact anatomical relation of the nerves, or rather to examine such a portion of them *as might be seen*, for instance, if the skin, fascia, and muscles were all transparent, and thus try quickly to refresh our memory by a bird's-eye view, as it were, *of the geography of the trunks* and *branches* of *the more superficial nerves.*

We know that the tri-facial, or fifth pair, after leaving the skull, spreads out into the most complex distributions and anastomoses. There are *three* principal branches. The *ophthalmic* branch passes forward through the outer walls of the cavernous sinus, lying externally to the other nerves, penetrates the bony orbit by coming out at the *sphenoidal fissure*, and then divides into three branches; and it is exactly at, or from this point that *neuralgia* oftentimes radiates flashes of excruciating pains. The lachrymal nerve, which is the smallest of the three branches of the ophthalmic trunk, communicates with the fourth nerve, passes along the upper border of the external rectus muscle, traverses the lachrymal gland, and then divides into two cuta-

neous branches. The superior branch of it passes through the malar bone, and comes out again to be distributed upon the anterior temple and the cheek. The inferior branch of it supplies the conjunctiva, and terminates in the integuments of the upper eyelid, also communicating with the facial nerve. But it is the superior branch, just described as mounting up to the temple, and there being lost in the integuments, that is the seat of the most frequent attacks of neuralgia. The *frontal branch* is the smallest of the ophthalmic third of the tri-facial nerve, and gives off but one branch, the *supra-trochlear*, which passes inward and over the pulley of the internal oblique eye muscle, and ascends then along the middle line of the forehead, very superficially, giving filaments to the skin, to the inner angle of the eye, root of the nose, and also to the conjunctiva. The exact ramification of the two branches of the frontal nerve can be distinctly traced as being separate as far as the vertex, where they terminate; and along the occipital suture many of the twigs interlace with the filaments of the sub-occipital nerve. The *nasal* branch of the ophthalmic plunges into the deep part of the orbit, and after crossing the optic nerve, enters the ethmoidal foramen, and seeks the nose through the slit-like *crista galli*, then dividing into two, the *internal* supplying the mucous membrane of the nose, about the opening of the nares, while the *external* branch is mostly distributed to the skin of the nose, even to its tip, and also giving a filament to the upper eyelid. Such is the superficial plot of the ophthalmic, or first branch of the great tri-facial.

The *second* and larger branch of the tri-facial we know is called the *superior maxillary* nerve. It comes out forward, through the *foramen rotundum*, enters the canal in the floor of the orbit, and runs out at the infra-orbital foramen. Emerging then on the face, just beneath the *levator labii superioris* muscle, it here immediately divides into multitudinous branches, thus diffusing itself mostly at and about its issue, but sending some filaments to the lower eyelid, to the conjunctiva, to the muscles and integuments of the upper lip, nose, and cheek, and finally forming anastomosis with the *portio dura*. True, there

are groups of branches given off from the superior maxillary as it passed the *spheno-maxillary fossa*, which give the posterior dental, &c.; also during its passage through the *infra-orbital canal*, which latter gives the middle and anterior dental; but it is the group that radiates on the face, giving the cutaneous and superficial muscular filaments, that we most need to study here. We often find occasion to know that there are considerable filaments furnished by the orbital branch of the superior maxillary, that ascends along the outer wall of the orbit, receiving there a twig from the lachrymal, then plunging through a canal in the edge of the malar bone to enter the temporal fossa, supplying the temporal muscles and fascia, and is finally lost in the skin of the temple and side of the forehead, but communicating with the *portio dura*, the auricular, and the temporal nerves. A posterior branch supplies the back teeth, the alveoli, and their gums. The middle and anterior dental branches, before their distribution, form the superior maxillary plexus, and from this the filaments are given off that supply the pulps of the teeth, the gums, alveoli, and the mucous membrane of the *floor* of the nares and the palate. But the *cutaneous* and muscular filaments are the true terminations of this nerve, not only supplying the muscles, the skin, and the mucous membrane of the cheek, nose, and lips, but also form intricate plexus with the more superficial branches of the *portio dura*, and hence are often neuralgic.

The *Vidian* or *Pterygoid nerve* is one, that is here of the utmost importance for our study. This nerve arises from the spheno-palatine ganglion, traverses the vidian canal of the sphenoid, and then divides into two branches. But it is only the *external* branch that particularly interests us. This is called the *superior cranial* or *nervus superficialis petrosus*, which ascends *into* the cranium, and enters the hiatus, to unite with the facial nerve. And let us be reminded that it is very near the point where these two nerves anastomose that the *chorda tympani* branches off. This superficial cranial branch of the vidian, according to Arnold, presents all the characteristics of a cephalic nerve in its whiteness and toughness of structure. Thus we find, even

in the interior of the ear, a considerable branch of the tri-facial which is liable to become neuralgic.

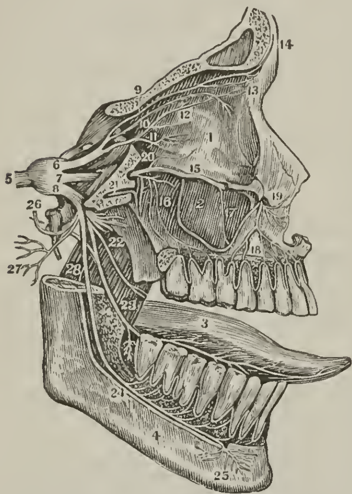


Fig. 69. The Tri-Facial Nerve, or Fifth Pair; giving a view of the Distribution of its three grand Trunks.

The *inferior-maxillary* nerve is the *third* great division of the tri-facial. It first escapes through the *foramen ovale*, and immediately divides into two principal trunks, the *external* and the *internal*, which are separated by the external pterygoid muscle. I should have said that the inferior maxillary branch of the tri-facial is partly motor; and it is in the *external* branch of this, that we find nearly the whole of its motor roots. This *external* branch divides at once into four branches, which are distributed to the temporo-maxil-

1. Orbit.
2. Antrum Highmorianum.
3. Tongue.
4. Lower Jawbone.
5. Root of the Fifth Pair, forming the Ganglion of Gasser.
6. First Branch of the Fifth Pair, or Ophthalmic.
7. Second Branch of the Fifth Pair, or the Superior Maxillary.
8. Third Branch of the Fifth Pair, or Inferior Maxillary.
9. Frontal Branch, dividing into the External and Internal Frontal Nerves.
10. Lachrymal Branch of the Fifth Pair.
11. Nasal Branch. Just under the figure is the long Root of the Lenticular or Ciliary Ganglion, and a few of the Ciliary Nerves.
12. Internal Nasal Nerve, disappearing through the anterior ethmoid foramen.
13. External Nasal Nerve.
14. External and Internal Frontal Nerve.
15. Infra-Orbital Nerve.
16. Posterior Dental Branches.
17. Middle Dental Branches.
18. Anterior Dental Branches.
19. Terminating Branches of the Infra-Orbital Nerve, also called the Labial and Palpebral Nerves.
20. Sub-cutaneous Malæ, or Orbital Branch.
21. Pterygoid, or recurrent Nerve from Meckel's Ganglion.
22. Five Anterior Branches of the Third Branch of the Fifth Pair.
23. Lingual Branch of the Fifth, joined by the Chorda Tympani.
24. Inferior Dental Nerve.
25. Its Mental Branches.
26. Superficial Temporal Nerve.
27. Auricular Branches.
28. Mylo-Hyoid Branch.

lary region. They are the *masseteric*, the *temporal*, the *buccal*, and the *internal pterygoid*. Then, again, the *internal branch* of the inferior maxillary divides into three branches, which are the *gustatory*, the *inferior dental*, and the *anterior auricular*. The gustatory supplies the side of the tongue, its papillæ, and the mucous membrane. The inferior dental passes on by the ramus of the lower jaw, enters the dental foramen, and runs along the bony canal in the jaw, giving off branches to the teeth and gums as it passes, and then terminates in two considerable twigs, the *incisive* and the *mental*. The former supplies the lower incisive teeth, while the mental branch escapes through the mental foramen, and there becomes superficial, to supply the muscles and skin of the chin, lower lip, and the mucous membrane of the lower lip; it also communicates with the *portio dura*.

Now, if we go back and trace the temporal, or the second of the four branches of the inferior maxillary, we find it at first turns around the posterior side of the neck of the lower jaw condyle, near the joint of the jaw, then goes up vertically between the articulation of the jaw and the anterior edge of the ear, where it becomes superficial, and then even sub-cutaneous, in the most superior portions of the temporal fossa. But at its root, and behind the condyle, it furnishes important anastomotic branches to the *portio dura;* thus uniting with the upper divisions of these motory nerves, to be together distributed and lost in the integuments of the temple, the surroundings of the eye, and in the upper lip. These deserve our particular attention, as likewise do the twigs of this nerve to the lobe of the ear, and those to the auditory cavity and pavilion, as also the communications with twigs from the cervical plexus, and from the lachrymal, sub-cutaneous malar, auricular, and facial nerves.

Neuralgic Points.—The, to us, *most important points* of the tri-facial nerve are, 1. The *point of exit* of the *lachrymal branch*, which is at the external part of the upper eyelid. This is what Dr. Valleix called the "palpebral painful point."

2. The *point of emergence* of the *frontal* nerve, or, rather, of its external branch, from the upper orbital foramen, called *the upper orbital point.*

37 *

3. The *point of emergence* of the *nasal* branch, which can be found at the upper part of the side of the nose, a little inside, and below the internal angle of the eye, and this is called the *nasal neuralgic point.*

4. The *malar* or inferior branch that *emerges* upon the cheek, through a groove in the malar bone, and passing through the fibres of the *orbicularis palpebrarum* muscle, is called the *malar neuralgic point.*

5. The *point of union*, in the interior of the ear, of a branch of the *superficial petrosal branch* of the *vidian* nerve, with a branch of the *portio dura* — a union which arises from the *chorda tympani*, and is designated as the *internal auricular neuralgic point.**

6. The point of emergence of the upper alveola and dental nerve, which may be called the *superior dental neuralgic point.*

7. The two very important points of emergence from bone are found first at the *infra-orbital foramen*, well known as the site of *tic douloureux*, and now called the *infra orbital neuralgic point;* the second is at the *mental foramen*, and called the *neuralgic point of the chin.*

8. The point in the *masseter* nerve branch, where it crosses

* I will remark here, — as we observe that this point is quite different from the superficial points, — that I think I find a *law*, that at the very point of bifurcation or *branching off* of nerves, as also at the point or larger spot of *anastomosing* and *interlacing*, that *there*, especially, (and next to the "points of emergence," and becoming superficial, as discovered by Valleix,) is the nerve more liable to become the seat of neuralgia, and that all the more according as these are more complicated at any given place. True, Dr. Valleix laid down *four different positions of a nerve* as most liable to become the seat of neuralgia ; but I do not see what portion of any superficial nerve is left out, if we define, first, "the point of emergence," second, "the course of the nerve branches through the muscle fibres to become superficial," third, "the point where the nerve becomes superficial," fourth, "the point where the nerve has its ultimate superficial distributions." Besides, this is not sufficiently definite for a rule in practice.

I think I am justified, therefore, in mentioning *seven points* in the course of nerves that are peculiarly liable to be the seat of neuralgic pains : —

1. The point of *emergence* of the nerve trunk from bone or any deep seat.
2. The point of *branching off.*
3. The point of becoming *superficial*, or running very superficially.
4. The point of *interlacing*, as for plexus and ganglia.
5. The point of *anastomosing* with other nerve fibrils.
6. The spot of *ultimate ramification in the integuments.*
7. The spot of *ultimate ramification in the fascia and muscle fibres.*

the sigmoid notch, on its way to the masseter muscle, and this is called the *temporo-maxillary neuralgic point.*

9. The point of the *temporal* branch of the inferior maxillary nerve found between the articulation of the jaw and the anterior edge of the ear passage, which is called the *temporo-auricular neuralgic point.*

10. The point of the *lingual* nerve branch is found where it emerges between the sub-lingual gland and the tongue, and is called the *lingual neuralgic point.*

11 and 12. There is one more vastly important point which I must here speak of and designate as the *crown point of neuralgia;* but this does not strictly nor exclusively belong to the trifacial nerve. This point (or limited region) is found at the interlacing between the last twigs of the *frontal* and the *superficial temporal* branches on the one side, with those of the greater and lesser occipital nerves on the other. This *large spot* lies over the *sagittal suture*, and almost directly above the parietal protuberance; it was called by Dr. Valleix the "parietal painful point." Thus we have noted the marked neuralgic points of the greatest *sensitive* nerve, in the whole human body.

The great *facial*, or *portio dura*, is rather a motor nerve; but it makes such numerous interlacings with the facial and the cervical, that it at one time bore the nickname of "*nervus sympatheticus minor*." Its trunk first emerges from the *stylo-mastoid foramen* and passes forward through the parotid gland, and at but a little under the ramus of the lower jaw it divides into two trunks, the *temporo-facial* and *cervico-facial.* These two trunks at once bifurcate into very numerous branches supplying the muscles of the face, forming loops mostly over the masseter muscle, and anastomosing with other nerves in its profuse ramifications over the peripheral regions of the face from the temple to the neck. It is at its first division into the two main branches, and just where it comes out of the parotid gland, which we find is close along under the angle of the lower jaw, that it may be designated as *the point most superficial* of the facial nerve. This is the most reachable point in cases of paralysis of this nerve.

Superficial Nerves in the Occipito-Cervical Region.

The first or highest four of the eight cervical nerves interest us here more particularly. It is the *anterior* branches of these upper four that, by loops of communication, go to form the great cervical plexus. This plexus we find to be situated upon the *levator anguli scapulæ* and *posterior scalenus* muscle, to be there partly covered by the posterior edge of the *sterno-mastoid*, but more completely by the *platysma*. The anterior branches of the *fifth*, *sixth*, *seventh*, and *eighth* cervical nerves will be examined with the *brachial plexus*, of which they form the greater part.

The *posterior* division of the first cervical nerve, also called the *sub-occipital* nerve, passes out of the spine between the occipital bone and the atlas, in the there triangular space, and at this spot forms a long ganglion *that connects with the second cervical*, and then divides into two branches, one of which soon becomes superficial, and again divides into a number of branches, which are all distributed to the integuments and muscles of the upper and back part of the neck; but the larger and longer branches mount upon the occiput and expand so as to cover the occipital region, and are traced even up to the parietal protuberance. The *anterior* branch of this first cervical nerve, and those of the three other upper cervical nerves, go, as we have said, to form the great anterior cervical plexus; but the *posterior* branches are those that just here most concern us. These not only form the smaller or *posterior* plexus, but seem to have an almost common destination; and that is, first, to supply the muscles of the back of the neck, to form numerous anastomoses, and then to become *cutaneous*. We find, by dissection, that the whole surface of the *nucha*, as high as the first four vertebræ, also as low down as to the seventh and eighth nerves, is occupied with a very remarkably profuse supply of these short posterior nerve fibres, that mostly terminate abruptly in the flesh, skin, and fascia along the spine, while their roots are thus embedded so near by in the spinal marrow.

The first *superficial nerve trunk* I will notice here, is the *super-*

ficialis colli, which is formed of united branches from the second and third cervical nerves; it is found by the electrode as it crosses obliquely behind the external jugular vein at the anterior border of the *sterno-mastoid* where it divides into an ascending and a descending branch; the latter is lost in the skin and fascia of the side and front of the neck, even to as low down as the clavicle; while the ascending branch passes upwards to the sub-maxillary region, and by very numerous branches they supply the integuments as high up as the chin and the lower part of the face; it then anastomoses with the facial nerve.

The second of the larger *superficial nerve trunks* here, is the *auricularis magnus*, formed also of the second and third cervical nerves. This first curves around the posterior border of the sterno-cleido-mastoideus, and then ascends upon that muscle parallel with the external jugular as far as the parotid gland, where it divides into an anterior and a posterior. The former is distributed to the integuments over the region of the parotid gland, and to the gland itself, connecting with the facial nerve and with the external ear. The *posterior* branch pierces the parotid gland, crosses the mastoid process, and then divides into many branches which are spread out upon the posterior region of the *pinna*, and the integuments of the side of the head and upper neck.

But the most *superficial* nerve trunk of all, in this region, is the *occipitalis minor*, which arises from the second cervical nerve. It also curves around the posterior border of the *sterno-cleido-mastoideus*, but above the preceding nerve, and ascends also upon that muscle parallel with its posterior border, where it is easily affected by the electrode; and from here it divides and is distributed to the muscles and skin of the region, namely, to the *occipito-frontalis*, *attollens*, and *attrahens aurem*, &c.

The next most important and *superficial* nerve trunks are, the *acromialis* and the *clavicularis*. These are found as two, or sometimes three, large nerves, which, at first, proceed from the fourth cervical nerve; but leaving the ganglion, they immediately subdivide into numerous branches, all of which pass downwards *over* the clavicle, and are distributed to the integuments of the

upper and anterior part of the chest from the sternum to the shoulder; as also in the *supra clavicular triangle.* The more muscular branches from the third and fourth cervical go to the *trapezius*, *levator anguli scapulæ*, and *rhomboidei* muscles.

To sum up the whole, in this region, then, the most marked *neuralgic points* are found, first, at the middle of the side of the neck on the posterior border of the *sterno cleido-mastoideus*, where these several up-running nerve trunks emerge to become superficial. Next, at the upper and lateral part of the *sterno-cleido-mastoideus*, just below its insertion, and about on a level with, but back of, the lower part of the ear, which is the point of the first superficial bifurcation of the *occipitalis minor* nerve. Next, we find a *neuralgic point*, a little above and back of that, a little outside of the first vertebra, which is the emergence of the *trunk* of the *occipitalis major nerve.* Next, a point in front of, or rather anterior, to that, and just a little back of the ear, where the electrode can be placed upon the *posterior auricular* branch; and then, again, a little lower down, on the middle of the upper portion of the *sterno-cleido-mastoideus*, where it rests upon the *auricularis magnus*, which is the great superficial ascending branch from the cervical plexus. Next is a *neuralgic point* on the anterior edge of the lower third of the *trapezius* muscle, at the point where the *spinal accessory* nerve gives off a large branch to the external surface of the *trapezius*, for there the nerve emerges, running downward and backward over the lower part of the expanse of that muscle. Next, at and about the pavilion of the ear, and at the mastoid process; and, finally, at about the *parietal protuberance.* This latter is a *neuralgic region* of the peripheric distribution and anastomosis of two nerves. There is another such region of surface terminal ramification and anastomosis over and about the *nuchæ*, particularly about the three first vertebræ. There is another such over the *trapezius*, where is distributed the spinal accessory branch; and another over the upper and anterior part of the neck, and peculiarly so in the supra clavicular triangle. Indeed, the *neuralgic region of peripheric distribution* is a characteristic of all wide-spreading superficial nerves; while *neuralgic points* appear to be limited

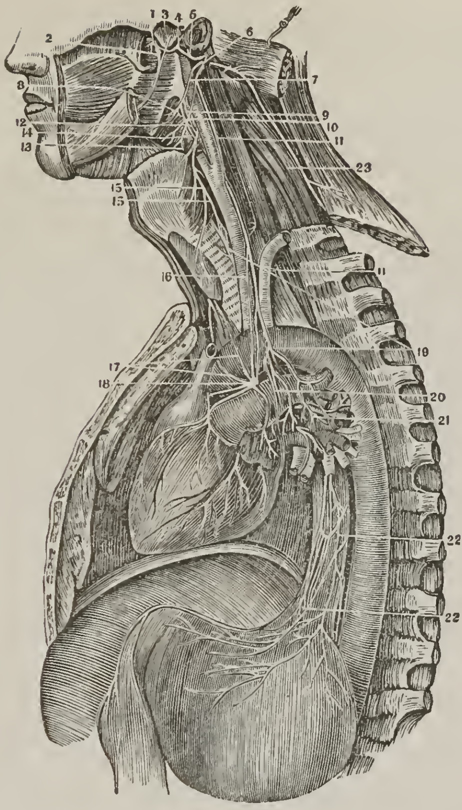


Fig. 70. A View of the Position of the Pneumogastric Nerve, the Glosso-Pharyngeal, and Spinal Accessory Nerves, or the Eighth Pair.

1. The Inferior Maxillary Nerve.
2. The Gustatory Nerve.
3. The Chorda Tympani.
4. The Auricular Nerve.
5. Its communication with the Portio Dura.
6. The Facial Nerve coming out of the Stylo-Mastoid Foramen.
7. The Glosso-Pharyngeal Nerve.
8. Branches to the Stylo-Pharyngeus Muscle.
9. The Pharyngeal Branch of the Pneumogastric Nerve descending to form the Pharyngeal Plexus.
10. Branches of the Glosso-Pharyngeal to the Pharyngeal Plexus.

15, 15. Communication of the Superior and Inferior Laryngeal Nerves.
16. Cardiac Branches.
17. Cardiac Branches from the Right Pneumogastric Nerve.
18. The Left Cardiac Ganglion and Plexus.
19. The Recurrent or Inferior Laryngeal Nerve.
20. Branches sent from the curve of the Recurrent Nerve to the Pulmonary Plexus.
21. The Anterior Pulmonary Plexus.
22, 22. The Œsophageal Plexus.

to the *trunks* of nerves, or to those more circumscribed in destination.

Since the *Pneumogastric* nerve trunk is most superficial *here*, I will add that the *functions* of this important nerve are, according to M. Longet, as follows: —

1. From its orign *above*, as far as the superior jugular ganglion, the pneumogastric is *exclusively* a nerve of sensation.

2. The stimulation of its proper fibres, as by the electricity, at their extremities, has *especially* the effect of inducing the *reflex movements* of deglutition, chymification, circulation, and respiration. At the same time it would be a serious error to suppose that, if the excitor influence of these fibres were cut off, the reflex motor actions would necessarily be abolished.

3. *Below* the superior jugular ganglion the trunk of the pneumogastric represents a mixed nerve, exercising a motor influence, voluntary on some organs, involuntary on others. The voluntary power it owes to its *direct* motor fibres; the involuntary, to the *indirect* before enumerated.

4. The sources of innervation required, to maintain the function of an organ, are multiplied in proportion to its physiological importance. Thus the organic movements of the lungs, heart, and stomach are influenced by motor fibres coming from numerous points of the nervous system. It is the same with the movements of deglutition, and with the respiratory dilatation of the glottis and uterus.

5. The anastomotic branch of the spinal accessory, which, to the exclusion of every other nerve, presides over the vocal movements of the larynx, only represents a partial motor root of the pneumogastric.

6. It is neither correct nor rational to conclude that, because, in the absence of this anastomotic branch, the phenomena of respiration, circulation, and digestion continue in animals, the pneumogastric nerve must be mixed at its origin. The internal branch of the spinal accessory is only one of the sources through which the trunk of the pneumogastric receives motor filaments from the cerebro-spinal centre. (See p. 477, and Appendix.)

Superficial Nerves in the Cervico-Brachial Region.

This neuralgic field embraces the whole *arm, hand, and shoulder*, up to the *occipito-cervical neuralgic region* on the one hand, as just described, and to the *dorsal neuralgic region* on the other. We said that the four *upper* cervical nerves were mostly involved in the last described region, and as such we have studied them; but we see here that the *lower four* of the eight cervical nerves, together with the first dorsal, go together to make up the starting point from the spine for the great *brachial plexus;* and

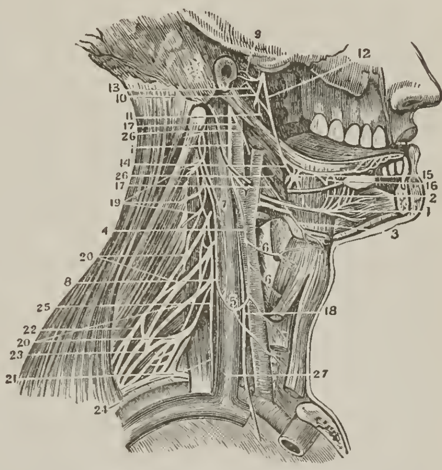


Fig. 71. A View of the Ninth Pair of Nerves, called the Hypo-Glossal; the deep-seated nerves of the neck are also seen.

1. The Hypo-Glossal Nerve.
2. Branches communicating with the Gustatory Nerve.
3. A Branch to the origin of the Hyoid Muscles.
4. The Descendens Noni Nerve.
5. The Loop formed with the branch from the Cervical Nerve.
6. Muscular Branches to the Depressor Muscles of the Larynx.
7. A Filament from the Second Cervical Nerve; and,
8. A Filament from the Third Cervical uniting to form the communicating branch with the Loop from the Descendens Noni.
9. The Auricular Nerve.
10. The Inferior Dental Nerve.
11. Its Mylo-Hyoidian Branch.
12. The Gustatory Nerve.
13. The Chorda Tympani passing to the Gustatory Nerve.
14. The Chorda Tympani leaving the Gustatory Nerve to join the Sub-Maxillary Ganglion.
15. The Sub-Maxillary Ganglion.
16. Filaments of communication with the Lingual Nerve.
17. The Glosso-Pharyngeal Nerve.
18. The Pneumogastric Nerve, or Par Vagum.
19. The Three Upper Cervical Nerves.
20. The Four Inferior Cervical Nerves.
21. The First Dorsal Nerve.

22, 23. The Brachial Plexus.

24, 25. The Phrenic Nerves.

26. The Carotid Artery.
27. Internal Jugular Vein.

hence are the *five spinal roots* of the nerves of the arm and hand.

We know, then, that the *brachial* or *axillary plexus* of nerves is formed by peculiar communications between the *anterior* branches of the four last cervical and first dorsal nerves; the fifth and sixth nerves unite to form a common trunk, which soon again divides into two branches; the last or eighth cervical and the first dorsal likewise unite, and soon again divide into two branches; the seventh cervical nerve passes outward between the two just described, and when opposite the clavicle it divides, and unites both with the one above and the one below, *and so unites the whole;* from which results the brachial plexus. This plexus is broad and deep-seated in the neck, but narrows and becomes superficial as it descends into the axilla, and then again enlarges some at its lower part, where it divides into its six terminal branches. It lies under the two *scaleni* muscles, between which its nerves issue, and lower down it is found placed between the clavicle and *sub-clavius* muscle above, and the first rib with the first serration of the *serratus magnus* muscle below. In the axilla this plexus is found situated by its outer border, resting against the tendon of the *sub-scapularis* muscle. At this point it completely surrounds the axillary artery by means of the two branches which are here sent off to form the nerve *medianus*.

Now, so very important is it for us to be familiar with the anatomical relations of the nerves of the upper extremities, that we must patiently review all the more important branches in the hand, arm, and shoulder. Commencing, then, at the roots of the arm nerves, we find there five pairs of spinal nerves, the fifth, sixth, seventh, and eighth cervical and first dorsal, whose *anterior* branches converge to form the great arm plexus. The *posterior* branches of the five pairs in question are far less in size and importance than the anterior; nevertheless, these small, short, and abrupt branches possess, here, no little interest for us. They at first set out merely vertically downwards, and then turn inwards between the muscles of the back, occupying the lower cervical and upper dorsal region, there throwing branches to the muscles as they pass, and then they

reach the surface *close along the spine*, and are reflected outward, to be distributed and lost in the integuments of the spinal region.

The larger *anterior* branches of these first five converge into the brachial plexus. From this plexus there go out together six terminal branches. These may be considered in two divisions; first, the humeral branches, or those that are found on the upper arm and shoulder; second, the descending branches, or those that supply the forearm and hand. Now, nearly all these nerves are in the first instance *motors*, i. e., first traversing and supplying the muscles; but they terminate by very many cutaneous branches of great importance. The first we notice are the *superior muscular nerves*, that go to the *sub-clavius*, the *rhomboid*, and the *levator anguli scapulæ* muscles. The next are the *short thoracic* nerves, (anterior,) which are two in number, and supply the *pectoralis major*, entering it, however, on its costal surface, and send twigs to the *deltoid*, as also to the deeper parts of the *pectoralis minor*. Next, we notice the *long thoracic* nerve, also called the *posterior thoracic*, or the *external respiratory* of Bell, passing down behind the plexus, but upon the broad *serratus magnus* muscle to its lowest serrations, where and in which it is lost, after supplying the whole muscle. Then we observe the *supra-scapular* nerve, descending from above the clavicle obliquely outward and downward to the *supra-scapular notch;* it then passes through the notch, crosses the *supra-spinous fossa*, beneath only the *supra-spinatus* muscle, (mark this!) and then passing in front of the concave margin of the spine of the *scapula*, it enters the *infra-spinous fossa*, and is distributed to the muscles *supra-spinatus* and *infra-spinatus*. Next are the *sub-scapular* nerves, two in number, distributed also to the muscle *sub-scapularis*. And, finally, still lower down on the shoulder, we find the "*inferior muscular nerves;*" they are only three branches, distributed to the *latissimus dorsi*, and the *teres major*. So much for the shoulder.

On the upper arm we notice the great "*external cutaneous*" nerve, which arises first in common with the *median nerve* from the cervical plexus, pierces the *coraco-brachialis* muscle, and

Fig. 72. A View of the Brachial Plexus of Nerves, showing its Branches to the Arm.

passes down between the *biceps* and *brachialis anticus* to the outside of the bend of the elbow; after supplying the integuments there, it perforates the fascia, and divides into two cutaneous branches. Thus the external cutaneous nerve first supplies the *coraco-brachialis*, the *biceps*, and *brachialis anticus* in the upper arm, and then the *integuments* of the outer or radial side (both the dorsal and palmar) of the forearm, from the elbow to the wrist, giving twigs also to the synovial membranes of the wrist joint.

The *internal cutaneous* nerve of the arm is smaller, and passes down the upper arm by the side of the basilic vein, giving off many cutaneous branches in its course. At about the middle of the upper arm it comes out of the deep fascia, and divides into several, all of which pass down the bend of the elbow, in front of or behind the *median basilic vein*, and descend in the course of the *palmaris longus* muscle, even to the front of the wrist, distributing branches to the integuments in their course, which is mainly on the palmar and outer margin of the forearm. The *lesser cutaneous nerve* arises from the great plexus, and is lost in the integuments back of the elbow, giving some twigs in its course to the middle posterior aspect of the

1, 1. The Scalenius Anticus Muscle.
2, 2. The Great Median Nerve.
3. The Ulnar Nerve.
4. The Branch from the Median to the Biceps Muscle.
5. The Thoracic Nerves; and just above is seen the Thoracic Loop, that supplies the Pectoralis Major and Minor Muscles.
6. The Phrenic Nerve, formed from the Third and Fourth Cervical.

upper arm, and connects with the first external *intercosto-humeral* nerve. (See p. 477, and Appendix G.)

The *median* nerve arises also from the axillary or brachial plexus, and descends along the upper arm by the side of the brachial artery, to the inner bend of the elbow, where it passes between the two heads of the *pronator radii teres* and *flexor sublimis digitorum* muscles. It then runs down the very middle of the palmar face of the forearm, between the *flexor sublimis* and *profundus* muscles, and also beneath the annular ligament, then into the palm of the hand, *and so on to the palmar surface of the fingers.* Thus the terminal twigs of the *median* nerve supply the important "exquisite *sense of touch*" to the pulp of the hand and fingers. It also supplies the periosteum about the elbow joint, and at the wrist it throws a branch around on to the posterior aspect of the wrist, where it joins a ganglion of nerves that there give off numerous small branches for the supply of this joint. There is also a *superficial palmar branch* that arises from the *median* at about the lower fourth of the forearm, that crosses *over* the

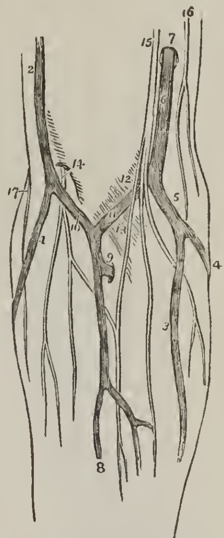


Fig. 73. A View of the Nerves, Arteries, and Veins at the bend of the Elbow, on the front of the Right Arm.

1. Lower Part of Cephalic Vein.
2. Upper Part of Cephalic Vein.
3. Anterior Basilic Vein.
4. Posterior Basilic Vein.
5. The Trunk formed by their union.
6. Basilic Vein piercing the deep Fascia at 7.
8. The Median Vein.
9. A communicating Branch between the deep Veins of the Forearm and the upper part of the Median Vein.
10. The Median Cephalic Vein.
11. The Median Basilic Vein. These regions can be seen.
12. Shows the *point* where the Three Branches of the Internal Cutaneous Nerve pass over, or in front of the Median Basilic Vein.
13. Shows the divergence of these Three Branches, under which is the Tendon of the Biceps, and under that lies the Brachial Artery.
14. The External Cutaneous Nerve coming out of the deep Fascia.
15. The Internal Cutaneous Nerve.
16. The Musculo-Cutaneous Nerve.
17. The Spiral Cutaneous Nerve, a Branch of the Musculo-Spiral.

annular ligament, to be lost on the skin of the palm of the hand, and over the ball of the thumb. As the principal branch of the *median nerve* reaches the palm of the hand, I should have said, it spreads out flattened, and divides there into six branches — one muscular and five digital. The *muscular* branch goes to the ball of the thumb. The *digital* branches first send twigs to the *lumbricales* muscles, and then become thus distributed: two pass outward to supply the palmar sides or edges of the thumb; one goes to the radial side of the index or fore finger; one other divides into four, two of which go to supply the neighboring sides of the index and middle fingers; while the other two go to supply the neighboring sides of the middle and ring fingers; so that the outer side of the ring finger, together with the little finger, goes unsupplied from this source. As the digital nerves course along the inner lateral side or edge of the fingers, when opposite the base of the first phalanx each nerve gives off a *dorsal branch*, which runs along the border of the dorsum of the fingers. Then, very near the extremity of the finger, each digital nerve divides again into two, — a final *palmar* and a *dorsal* branch, — the former supplying the *sentient fibres* for the pulpy integuments of the balls and tips of the fingers, while the latter supplies the root of the nail, and the structures around and beneath it. *No*

Fig. 74. A View of the Nerves on the Front of the Forearm.

1. The Median Nerve.
2. Anterior Branch of the Musculo-Spiral, or Radial Nerve.
3. The Ulnar Nerve.
4. Division of the Median Nerve in the Palm to the Thumb, First, Second, and Radial Side of the Third Fingers.
5. Division of the Ulnar Nerve to the Ulnar Side of the Third, and to both sides of the Fourth Fingers.

digital nerve ever holds any communication with its fellow on the opposite side of the finger; hence each gives an independent impression; in effect, this arrangement is, as it were, "*a jury of ten*," which certainly ought to give far more uniform and reliable judgment, than if every each were influenced by his fellow.

The *ulnar nerve* arises also from the brachial plexus, and passes along down the upper arm a very little back of the *median* nerve, but diverging from it more and more until it reaches the groove between the *internal condyle* and the *olecranon*, and crossing upon the internal head of the *triceps extensor*. Exactly at the under and back part of the elbow, this nerve is quite superficial, lying supported by the *inner condyle* of the elbow joint, against which it is easily compressed, as is often done by accident, giving rise to the thrilling sensation along the inner side of the forearm and little finger, usually ascribed to hitting the "funny bone." From this point the ulnar nerve passes between the two heads of the FLEXOR *carpi ulnaris*, and descends along the inner side of the forearm; crossing the annular ligament at the wrist, it divides into two branches — the superficial one going to the fingers by three terminal branches; the one of which is distributed to the ulnar side of the little finger; one goes to the neighboring borders of the little and ring fingers, and a filament to join the palmar median. The deep palmar branch passes between the *abductor* and *flexor minimi digiti*, to the deep palmar arch,

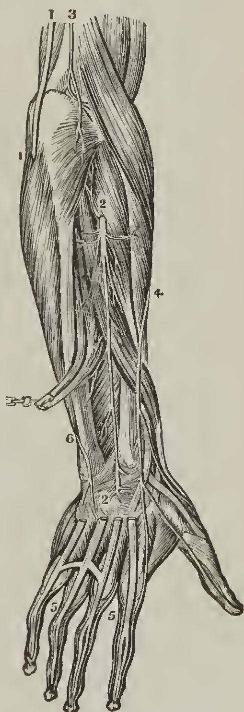


Fig. 75. A View of the Nerves in the Back of the Forearm, and Hand.

1, 1. The Ulnar Nerve.
2, 2. The Ramus Profundus Dorsalis Nerve.
3. Termination of the Nervus Cutaneus Humeri.
4. The Dorsalis Carpi — a Branch of the Radial Nerve.
5, 5. Digital Nerves — a back view of them.
6. Dorsal Branch of the Ulnar Nerve.

supplying the muscles of the little finger, and the *interossei*, and other deep structures in the ulnar side of the palm of the hand. There is also a *dorsal* branch of the ulnar nerve at the lower third of the forearm, that passes backward beneath the tendon of the *flexor carpi ulnaris*, and divides into two branches which supply the integument along that side of the forearm, besides two fingers and a half, on their posterior aspect. Another *anastomotic* branch of the ulnar nerve arises about midway down the forearm, and this divides into two; the one accompanies the ulnar artery, the other pierces the deep fascia outwards, and is distributed along the integument.

The *musculo-spiral* nerve is the largest branch of the brachial plexus. It passes downward in front of the tendons of the *latissimus dorsi* and *teres major* muscles, then winds around the humerus in the spiral groove to the space between the *brachialis anticus* and *supinator longus*, and thence downwards to the bend of the elbow, where it divides into two, the *posterior interosseous* and the *radial* nerve. The branches of the great *musculo-spiral* are, first, the *muscular*, which are distributed to the *triceps*, to the *supinator longus*, and to the *extensor carpi radialis longior*. The next is the *spiral cutaneous*, that becomes superficial just below the insertion of the *deltoid* muscle, and this passes down the outer side of the arm and forearm as far as the wrist, and is lost in the integument. The next branch forms the *radial* nerve, which runs along the radial side of the forearm to the beginning of the lower third of it; and here it passes beneath the tendon of the *supinator longus*, but at about two inches above the wrist joint it comes out again, piercing the deep fascia, and dividing into two branches. The external of these is distributed to the upper and outer or radial border of the hand and thumb. The internal branch crosses obliquely on the dorsum of the tensor tendons of the thumb, and divides into several filaments for the supply of the ulnar border of the thumb, the radial border of the index finger, and the neighboring borders of the index and middle fingers. The *posterior interosseous* branch separates from the *radial* at the bend of the elbow, as soon as

it leaves the parent trunk, pierces the *supinator brevis* muscle, and emerges from its lower border rather on the posterior of the forearm, where it divides into two branches, which supply the whole of the muscle on the posterior aspect of the forearm. The longest branch of this, called the *ramus profundus dorsalis* nerve, descends to a little below the posterior aspect of the wrist, where it forms a large gangliform swelling, (as often observed in nerves that supply joints,) and from which numerous branches are distributed to the wrist joint.

The *circumflex* or axillary nerve, arising from the brachial plexus, also passes downwards, but *over* the border of the *subscapularis* muscle, then winds around the neck of the humerus, and divides into numerous branches, which supply the muscle *deltoideus*. The branches of the circumflex nerve are both muscular and cutaneous. The muscular branches go to the *subscapularis*, *teres major*, *latissimus dorsi*, and the *deltoid* muscles. The *cutaneous* branches pierce the deltoid muscle after traversing its fleshy fibres, and are lost in the integument of the shoulder. One of these, which is the largest, (*cutaneus brachii superior*,) winds around the very posterior border of the *deltoid*, and divides into many filaments, which pass in a radiating direction across the back of the shoulder, and are lost in the skin of those parts, and particularly over the upper region of the deltoid.

The *neuralgic points* then, most to be noticed are, first, the terminal cutaneous nerve region of the posterior branches along the lower cervical and spine muscles. Second, a *neuralgic spot* over the spine of the shoulder blade, where the *supra-scapular nerve branch passes in front of the concave margin of the scapula*, to enter the *infra-spinous fossa*. Third, a *neuralgic spot* close under the outer end of the *clavicle*, where lies the lower end of the great *brachial plexus*. Another spot in the *upper anterior axilla*. Another on the *inner anterior neck of the humerus, where the several large nerve trunks for the arm first leave the great plexus, and here become superficial*, which makes them at once liable to neuralgia, but also accessible to the electrodes. Fourth, a *neuralgic spot* on the *pectoralis major* muscle, where the *loops* of the *anterior thoracic nerves* are lost in its

upper fibres. Fifth, a *neuralgic spot quite on the side of the chest*, and just by the anterior edge of the *serratus* muscle, where the long thoracic nerve trunk (external respiratory of Bell) is superficial on its way to the farthest serrations of this great respiratory muscle. Sixth, a *neuralgic spot immediately at or below the insertion of the deltoid muscle into the humerus, where the spiral cutaneous nerve emerges to become superficial.* Seventh, a *neuralgic spot over the border of the sub-scapularis muscle, extending to the posterior portion of the deltoid*, where the terminal branches of the axillary or circumflex nerve are lost in the integuments and superficial fleshy fibres of that region. Eighth, a *neuralgic spot on the middle of the posterior aspect of the upper arm*, where the lesser cutaneous nerve of Wrisberg emerges and becomes superficial. Ninth, a *neuralgic spot along the inner border of the whole upper arm, but more particularly at a point just above the bend of the elbow, and by the inner side of the tendon of the biceps muscle, where the great medianus nerve trunk becomes most superficial.* Tenth, a *neuralgic spot on the dorsal and radial aspect of the wrist and hand, where the dorsalis carpi*, which is also known as the *dorsal branch* of the radial nerve, mounts obliquely upon the extensor muscle of the thumb, and runs along superficially to the back of the thumb and fore finger. There is another liable to be a *painful spot* at the back of the wrist joint, over the nerve ganglia there; but this is not so frequently neuralgic, as rheumatic. (See p. 477, Note B.)

Superficial Nerves in the Dorso-Intercostal Region.

There are *twelve* dorsal nerves on each side of the body: the first or upper one leaves the spine between the first and second dorsal vertebræ; the last or lowest one from between the *twelfth* dorsal and first lumbar vertebræ. These are distributed to the back, sides, and front portions of the body, both supplying the muscles and skin from the shoulder above, to the crest of the ilium below. This maps out the whole field of what is designated as *Dorso-intercostal Neuralgia.*

As each dorsal nerve root escapes from its inter-vertebral foramen in a downward and outward direction, the trunk immediately divides into two main branches, much as we have seen in the eight above; the one is called the *dorsal* or back branch, while the other constitutes the true *intercostal nerve.* The short posterior *dorsal branches* pass directly out backward, first distributing to the back muscles, and even to the deep *erector spinæ;* they then terminate profusely in the integument of this middle portion of the back, and even in the integument of the lumbar region in and near the middle line; so also some *external branches* are distributed to the skin and fascia upon the sides of the lumbar and gluteal region.

The *twelve intercostal nerves*, after receiving a filament each from the adjoining ganglia of the sympathetic, pass separately forward, running along in the intercostal spaces between the ribs, supplying the muscles as they pass, some terminating at the anterior termination of the intercostal space near the sternum; at this point the longer branches pierce the intercostal and pectoral muscles, then turning more downward and outward, are distributed to the integument of the mamma, and over the front of the chest. Those lower down, which are situated between the false ribs, pass behind the costal cartilages, and then outward between the muscles *transversalis* and the *obliquus internus*, then supplying the *rectus abdominis* muscle, and the integuments over the front of the abdomen. The first and last dorsal nerves come short of all this distribution. The branches of each intercostal nerve are, first, a *muscular branch*, (which has no cutaneous twigs;) and, second, a *cutaneous branch*, which is given off to become superficial *at about the middle of the arch of each of the ribs.* The cutaneous branches of the upper *three* intercostal nerves are not distributed on the body, but rise to radiate on the back of the upper arm, and hence are called the *intercosto-humeral* nerves. One of these is of a large size, and is widely distributed over the integuments of the back and inner aspect of the upper arm, as far down as the elbow. Another smaller branch is distributed to the integument of the extreme tip of the shoulder. One

other filament can be traced to the skin and fascia of the mamma. The *cutaneous* branches of the *fourth* and *fifth* intercostal nerves send anterior twigs to the integument of the mammary gland, and posterior twigs to the scapular region of the back. Then the cutaneous branches of the remaining, or lower *seven* intercostal nerves, arrive at the surface from between the serrations of the *serratus magnus* muscle above and the *external oblique* below, and these spread both backward and forward to all the surface of this anterior and lateral portion of the body. But the *cutaneous branch of the last dorsal nerve is remarkable for its size, and its ready response to the electrode*. It pierces the *internal* and *external oblique* muscles, and at once becomes superficial; then crossing the superior crest of the ilium, it is thrown into the integument over the dorsum of the ilium and of the gluteal region even as low down as the *trochanter major*.

To sum up, then, we find the *rule*, as first laid down by Dr. Valleix, that there are in each dorsal nerve three principal points, — i. e., that one is a point of "emergence," one of "superficial," and one of "distribution." The first is along the side of the spine over the intervertebral foramen, the second on the middle arch of the ribs, and the third along the side of the *sternum* and *linea alba*.

The first *series of neuralgic points* in the dorsal region, are found along the side of the spine, over the spot where these nerves emerge, which is about one inch from the side of the spinous process. The second *neuralgic spot*, here, is found along the back muscles, where are distributed to the skin all those short terminal twigs of the posterior branches of the dorsal nerves. The third great *neuralgic spot*, or *spots*, are found over the middle of each intercostal space; that is, at about the most prominent bend of the ribs, where the *cutaneous branch* bifurcates to become superficial. The fourth *neuralgic spot* is found but a little to either side of the sternum, or *linea alba*, where the terminal twigs of all the intercostal nerves become sub-cutaneous, and are reflected backward and forward over the integument, through all that region: particularly is this so just under or below the mamma; and that *is far more frequently*

observed on the left than on the right side. Another particular spot so abundantly supplied with surface filaments is *over the region* of the stomach, the pain there being more frequently ascribed to that viscus; another is near the umbilicus, and the pain there is often ascribed to the underlying bowels. The fifth *neuralgic spot*, in this field, is that just over the upper and anterior part of the crest of the ilium, where the last great *cutaneous branch* of a dorsal nerve *emerges*, so that its trunk is there superficial, lying on the external oblique muscle, to cross over to the dorsum of the ilium, and be broadly radiated in the *integument* over the great *glutei* muscles. (See Appendix F, G.)

Nerves of the Lumbo-Sacral and Abdominal Region.

In this *neuralgic field* we have to look at the remaining lower *eleven* pairs of spinal nerves. *Five* of these are *lumbar*, while *six* pairs are *sacral*. From the lumbar nerves results the great *lumbar plexus;* from the latter, the *sacral plexus;* then from these result the great nerve trunks of the lower limbs. But here we will confine our anatomical review to the "pelvic region," including the five lumbar vertebræ, the sacrum, and the sides of the pelvis, the lower part of the abdomen, and the genital organs.

Each of the *five lumbar nerves*, as they leave the intervertebral foramen, communicates first with the lumbar ganglia of the sympathetic, and then the *anterior* branch of each of them passes obliquely outward and downward back of the *psoas magnus* muscle, but underneath or in front of the *quadratus lumborum*, to both of which it sends a nervous supply. The first *posterior* lumbar branches pass directly backward from between the transverse processes of the vertebræ, and here each divides into two. The internal of these first supplies the *multifidus spinæ*, and the *interspinales*, then becomes cutaneous, and supplies the integument of the "hollow of the back," or lumbar region, on or near to the middle line. The external twigs of these *posterior* branches anastomose frequently, and so form loops, and after supplying

the muscles, they pierce the *sacro-lumbalis* outward, to reach the *integument* of the lumbar and upper sacral region, to which these also are finally distributed. The longer *branches* of the primitive five *anterior* nerve trunks that branch off while between the flat surfaces of the *psoas magnus* muscle, which lies beneath or beyond them, on the one hand, and the *quadratus lumborum*, that is over them, on the other, also form numerous anastomoses and loops, which, together with the last dorsal, constitute there the lumbar plexus. From this plexus there go out several branches that very particularly interest us here.

The first are the *musculo-cutaneous nerves*, which are two in number, and known as the *ilio-scrotal*, and the *ilio-inguinal*. These pass together, and mostly from the upper lumbar nerves to the middle of the crest of the *ilium*, and there piercing the *transversalis* muscle, they each give off a cutaneous branch that passes over and out, to be lost in the integuments of the

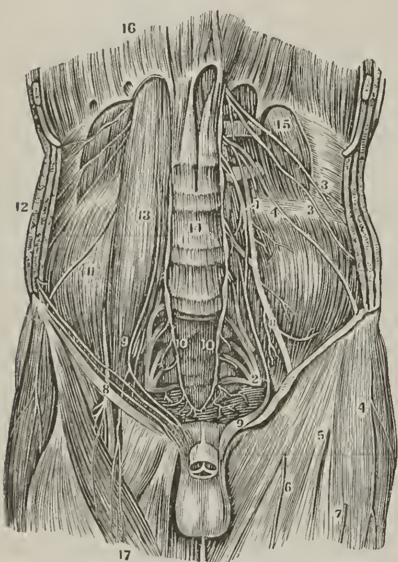


Fig. 76. A View of the Lumbar and Ischiatic Plexuses, showing the Branches of the former.

1. The Lumbar Plexus.
2. The Ischiatic Plexus.
3, 3. Abdomino-Crural Nerve.
4. The External Cutaneous Nerve, (Inguino-Cutaneous.)
5, 6, 7. Cutaneous Branches from
8. The Anterior Crural Nerve.
9. The Genito-Crural Nerve, or Spermaticus Externus.
10, 10. The Lower Termination of the Great Sympathetic.
11. The Iliacus Internus Muscle.
12. The Three Broad Muscles of the Abdomen.
13. The Psoas Magnus Muscle.
14. Bodies of the Lumbar Vertebræ.
15. The Quadratus Lumborum Muscle.
16. The Diaphragm.
17. The Sartorius, crossed by Branches of Nerves from the Crural, also om the Spermaticus.

upper and back portions of the hip. The main trunk of the musculo-cutaneous then winds along the crest of the ilium between the *transversalis* and the *internal oblique*, and at this point it divides into two branches — the *abdominal* and the *scrotal*. The abdominal branch runs forward parallel with the last dorsal or intercostal nerve, to near the rectus muscle, and supplying the muscles in its course, it then is distributed finally in the integument of the *mons pubis* and the folds of the *groin*. The *scrotal branch*, after communicating with the *inferior musculo-cutaneous* nerve, passes forward to the abdominal ring. It then pierces the *cremaster* muscle, and accompanies the spermatic cord in the male, and the round ligament in the female, to be distributed to the integument of the *scrotum* or the *external labium*. Such is the distribution of the *ilio-scrotal* nerve. The other musculo-cutaneous nerve, viz., the *ilio-inguinal*, passes at first obliquely across the *quadratus lumborum*, below the former nerve, to the anterior superior spinous process of the ilium, resting in its course upon the iliac fascia; but here it pierces the fascia and muscle of the transversalis outwards, and connecting with the scrotal branch of the *ilio-scrotal* nerve, it passes along the spermatic canal with the spermatic cord, to be distributed with it.

The *genito-crural nerve* proceeds mostly from the second lumbar, and passes downward and forward on the psoas muscle to Poupart's ligament, and divides there into two main branches — the *genital* and the *crural*. The *genital branch* (*spermaticus seu pudendus externus*) arrives at the internal abdominal ring, and descends along the spermatic canal, lying behind the cord to the scrotum, where it branches off to supply the spermatic cord and cremaster muscle in the male, and the round ligament and external labium in the female. Thus the scrotal branch of the musculo-cutaneous nerve and the genital branch of the genito-crural nerve together supply those important parts. At the abdominal ring, the genital branch sends off a large twig to the integument of the groin. The crural branch of the genito-crural goes to the thigh, and will there be considered.

We now come to the last six of the thirty-one pairs of spinal

nerves. These six pairs are known as the *sacral nerves.* The upper one, called the first, escapes from the vertebral canal through the first *foramen* in the sacral bone; the second, third, and fourth through their foramina; the two last from between the sacrum and the coccyx. These *anterior* branches interlace among themselves, and, with the lumbo-sacral, go to form the sacral plexus. Then from *it* are sent off to this neuralgic region the *visceral nerves*, which are in some three or four large branches, and arise mostly from the fourth and fifth sacral foramina; these ascend upon the *side* of the rectum and the urinary bladder; in the female upon the side of the rectum, the vagina, and the bladder. The *muscular nerve* branches go to the *levator ani* muscle; the *hemorrhoidal* nerve passes through the two ischiatic openings, and goes to the terminal portion of the rectum; also supplying the *sphincter ani muscle*, and the integument just about the anus.

The *internal pudic nerve* arises from the lower part of the sacral plexus, passes out of the pelvis through the great sacro-ischiatic foramen, below the pyramidalis muscles, and divides into two branches. The upper one (*dorsalis penis*) turns under and upwards to ascend along the posterior surface of the ramus of the ischium, and with the *arteria dorsalis penis* goes to the glands, in which it is distributed. At the very root of the organ this nerve gives off a cutaneous branch, which runs along its side, giving branches to the *corpus cavernosum*, and then, with its fellow of the opposite side, supplies the integument of the upper two thirds of the penis and prepuce. The interior branch of the pudic nerve divides, while in the perineum, into three principal twigs. The one ascends upon the outer side of the *crus penis*, and is lost in the scrotum. A second, called the *superficial perineal* branch, gives twigs to the scrotum, to the integument of the under part of the penis, and to the prepuce. The third branch, called the *bulbo-urethral nerve*, sends twigs to the *sphincter ani*, *transversus perinei*, and to the *accelerator urinæ*, and then terminates by profusely ramifying the *corpus spongiosum*. In the female, these branches of the internal pudic nerve are distributed to the parts analogous

to those of the male. There, the superior branch supplies the clitoris, while the inferior goes to the vulva and parts in the perineum. (See Appendix E.)

The *lesser ischiatic nerve* passes out of the pelvis with the internal pudic. One of its cutaneous branches curves around the tuberosity of the ischium, ascends to the scrotum, and there divides. One branch is distributed to the inner surface of the scrotum, and to the testis. The external branch goes to its outer side, and both terminate in the integument of the under border of the penis, or, in the female, to the vulva.

To sum up, then, we find that the lumbar nerves give some large *posterior branches*, which are distributed to the loins, the sacrum, and nates; also, that the *three musculo-cutaneous branches* give off those that go to the muscles of the lower abdomen, to the folds of the groin, and to the scrotum or pudendum; another branch to the integument of the lower abdomen, and another to the skin of the upper and inner thigh. A genito-crural nerve-branch also goes to the integument of the scrotum, the groin, and the thigh. Then the sacral nerves give branches to parts in the vicinity of the coccyx; also posterior branches to ramify the muscles and integuments of the nates. Of these are the *hemorrhoidal nerves* to the rectum, the *vesical* to the bladder, the *uterine* and *vaginal nerve* branches to the vagina and uterus. A branch of the inferior gluteal goes to the *perineum*, and the integuments of the posterior parts of the thigh. Then there is the *pudic nerve* to the perineum, and to the penis, or vulva.

The most important *neuralgic spots* in this region are, first, *a series of points along the side of the spinous processes*, and but a little removed from the median line where the posterior branches of the lumbar and sacral nerves *emerge* from their bony passage — the former pierce the *lumbo-sacralis*, to become distributed to the integument over them; and again, *a neuralgic extent* along and near to the median line over their ultimate cutaneous distributions; and again, *a neuralgic spot* at the posterior part of the crest of the ilium, where some of the lumbar branches pass over its edge very superficially, and

almost vertically, to be distributed to the skin and superficial fascia of the gluteal region. Next, we find *a neuralgic spot* at the highest and middle point on the crest of the ilium, where the great *musculo-cutaneous nerve* gives off a large superficial branch.

Next, there is *a neuralgic point* at the anterior superior spinous process of the ilium, above the groin, where the *musculo-cutaneous nerve* gives off its abdominal branch, which is distributed to the *mons pubis*, the folds of the groin; and near here, too, the scrotal branch anastomoses, which is very liable to be a neuralgic spot. Another very liable *point is at the external abdominal ring*, (which may extend along the course of the spermatic cord,) where the scrotal nerve branch emerges from under the cremaster muscle to accompany the spermatic cord in the male, and the round ligament in the female, then to be finally distributed in the integument of the *scrotum* of the former, or in the *external labium* in the latter. The *ilio-scrotal nerve* also is often neuralgic, and excessively painful along the course of it *from the abdominal ring to the groin.* But perhaps the most frequently *neuralgic spot* we find in this region is *that over the internal abdominal ring*, *where the genito-crura nerve comes out a very little below Poupart's ligament;* from there this nerve descends to be ultimately distributed to the skin and fascia on the top and front aspect of the thigh as far as half way down to the knee. (See B, E.)

Rule.—In treating these painful points and regions, *begin* the *seance* with the positive electrode placed *at* or *above* the highest painful point, while the negative is *below* or beyond the lowest site of pain; then move the positive, from minute to minute, towards the negative, until it is *below* the lowest site of pain.

Nerves of the Sciatico-Femoral Neuralgic Region.

This simply embraces the lower limb. We have here then but two great nerve trunks to consider, viz., the *femoral nerve*, (crural,) on the inner and anterior aspect of the limb, and the great *ischiatic* (sciatic) *nerve*, on the posterior and outer aspect of the limb. The roots of these two great nerves are interpelvic, arising from the lumbar and sacral plexuses; and as the

anterior or *femoral nerve* springs mostly from the lumbar plexus, we will review this first. This nerve is the largest branch from the lumbar plexus; it *emerges* beneath Poupart's ligament into the thigh, just above the groin, where it is flattened, but immediately subdivides into a great number of branches, almost all of which are superficial. Of its first branches are *the cutaneous nerves*, two in number, which, after perforating the *sartorius* muscle, and there giving filaments, pierce the *fascia lata*, and are then distributed to the integuments of the anterior inner aspect of the thigh, over its middle and lower part, even down to the inner side of the knee. The most superficial branch is the *perforans*, that comes out of the upper part of the sartorius, and there communicates with the *genito-crural* nerve, then divides into many branches, which supply the surface of the anterior and outer aspect of the limb as far as the *patella*. Another branch comes out of the fascia lata at the lower third of the thigh, and descends over the inner condyle of the knee joint, and curves forward around to the front of the knee, terminating just below the patella. Besides these, there is an important surface branch, derived from the muscular branch that supplies the *vastus externus* muscle, which is found radiated to the integuments over the outer side of the lower third of the thigh. The *muscular* branches

Fig. 77. A View of the Femoro-Crural Nerve, showing also its Branches.

1. Point where this Nerve comes out under Poupart's Ligament.
2. Division of the Nerve into its numerous Branches.
3. The Femoral Artery.
4. The Femoral Vein.
5. The Branches of the Obturator Nerve.
6. The Nervus Saphenus.

go to the muscles on the anterior of the thigh, as to the *rectus femoris*, the *vastus externus* to the *cruræus*, and a long branch to the *vastus internus;* and from this nerve large filaments go to the *periosteum* about the knee, and to the knee joint. We see that the *sartorius* receives its supply from cutaneous twigs. The branch to the *femoral sheath* enters it at once near the groin, and there surrounds the femoral artery and vein, and the profounder vessels; some of these re-unite and escape from the saphenous opening to pass downwards with that vein; others are distributed to the adductor muscles, and connect with the long saphenous nerve. The *short saphenous nerve* descends on the inner border of the sartorius to the lower third of the thigh, and is lost about the knee joint; but one branch accompanies the femoral vessels to the point opposite the termination of the femoral artery, where it divides and anastomoses with other nerves, as the obturator, &c., so as to form there a plexus, and from this, branches ramify the integument upon the internal and posterior aspect of the lower thigh. The *long saphenous nerve*, (*cutaneus internus longus*,) after leaving the femoral nerve trunk, accompanies the femoral artery to the aponeurotic canal formed by the *adductor longus* and the *vastus internus* muscles. It here quits the artery, passes between the tendons of the *sartorius* and *gracilis* muscles, descends along the inner side of the leg down to the front of the inner ankle, and is distributed to the integument *over the inner side of the foot*, as far as the great toe. But there is first a *tibial cutaneous branch* from this, that branches off a little above the internal condyle at the knee, and passes down, giving a constant supply of surface twigs over the inner aspect of the leg, even to the ankle; also another short branch that supplies the synovial membrane of the knee joint; also another that supplies first the integument over and about the patella and around the knee; then the skin and fascia on the front and outer aspect of the leg as far down as the ankle; and lastly, some cutaneous branches that come off from the long saphenous a little below the knee to supply the integument on the inner side and front of the leg and foot, and to give *articular* branches to the ankle joint.

We must here notice again *the obturator nerve*, which arises from the lumbar plexus, and with the obturator artery escapes from the pelvis to supply first the *obturator externus*, then passing in front of the *adductor brevis* muscle, supplying the *adductor longus* and the *gracilis*, and a branch ramifies the *adductor magnus;* then, from this, *a long cutaneous branch* proceeds to the plexus of the short saphenous nerve, and gives nervelets to the integument all along the inner side of the calf of the leg; but, before this, it gives some branches to the synovial membrane on the posterior aspect of the knee joint.

The *great ischiatic nerve*, excepting the brain and spinal marrow, is the largest nervous cord in the human body. It has its roots in the sacral and lumbar plexuses, but more directly from the latter. It is, indeed, the great prolongation or extension of the lower spinal nerves, but its large size forms only at, and not before its exit from the great *sacro-ischiatic foramen*, where it measures three quarters of an inch in breadth. It descends from beneath the *pyriformis* muscle, through the middle of the space between the *trochanter major* and the *tuberosity* of the *ischium*, and so along down the posterior aspect of the thigh, to about its lower third, where we see it divides into two, the *popliteal* and the *peroneal* branches. This division sometimes occurs farther up, but its course is always the same. The nerve in this route down the thigh rests upon the *gemellus superior*, the tendon of the *obturator internus*, *gemellus*

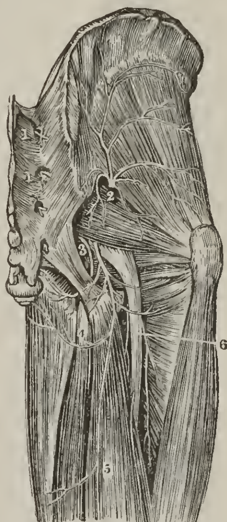


Fig. 78. A View of the Great Sciatic Nerve, also showing other Branches of the Ischiatic Plexus to the Hip and Back of the Thigh.

1, 1. The Posterior Sacral Nerves.
2. Nervi Glutei.
3. The Internal Pubic Nerve.
4. The Lesser Ischiatic Nerve, giving off the Peroneal Cutaneus, and,
5. The Ramus Femoralis Cutaneus Posterior.
6. Great Ischiatic, more frequently called the *Sciatic Nerve*.

inferior, *quadratus femoris*, and the *adductor magnus* muscles; while it is covered in, first by the *gluteus maximus*, then for a space by the *biceps*, and all along by the *semi-tendinosus* and *semi-membranosus*. The first branches from it supply the external condyle of the femur, and after this they pass on down to be distributed to the fibrous capsule, and to the synovial membrane of the outer side of the knee-joint.

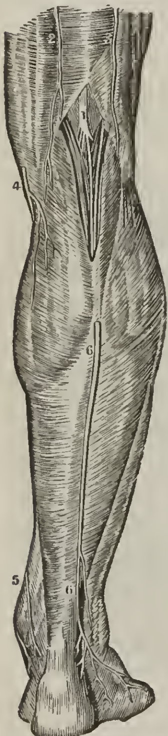


Fig. 79. A View of the Popliteal Nerve, showing also some of its Branches.

The *lesser ischiatic nerve* passes out of the pelvis through the great sacro-ischiatic foramen also, and near by the side of the *great sciatic* nerve. These more local and superficial nerves curve their branches both backward and forward, to be distributed in the neighborhood of the hip. It first supplies the *gluteus maximus* even to its upper border under the crest of the ilium, while other branches turn backwards about the coccyx, and others go still farther down on the back of the thigh and leg. The *middle posterior cutaneous nerve* is one branch of it, and curves around and over the tuberosity of the *ischium* in company with the *scrotal* branch, then passes downwards superficially along the middle posterior aspect of the thigh, to be distributed to the integument along in the popliteal region both to the sides and back of the bend of the knee, and down as far as the middle of the calf of the leg.

The *popliteal nerve* is the "continuation" of the great ischiatic, from that point where the ischiatic (sciatic) nerve divides, to the arch of the *soleus*, from whence, it is then called the *posterior tibial nerve*. The popliteal nerve trunk is very superficial in all its course, and

1. The Popliteal Nerve.
2, 3. The Terminations of the Ramus Femoris Cutaneus Posterior.
4, 5. The Internal Saphenous Nerve, a Branch of the Crural.
6, 6. The External Saphenous, or Communicans Tibiæ.

is found external to the vein and artery. The branches are for muscular, articular, and cutaneous ramifications. One branch supplies the interior of the knee joint. The *communicans* is a large branch of the popliteal, which interlaces with a large branch from the peroneal nerve, (which is from the femoral,) and these two together constitute the roots of the *external saphenous nerve*. Then this external saphenous becomes superficial on the upper middle of the posterior calf of the leg, rather inclining to the *outer* border of the *tendo Achillis;* it then winds around the outer *malleolus*, and is distributed superficially to the *outer* side of the foot as far as the little toe. The popliteal nerve also gives off the *posterior tibial nerve*, which runs deep-seated until it arrives at the ankle, after passing down the *inner* side of the *tendo Achillis;* and here some *cutaneous* branches pass down the inner side of the *os calcis*, to be lost in the integument of the heel. There are some branches of the posterior tibial nerve that entwine about the fibular artery, and supply the *flexor longus pollicis*, and then become superficial, to be distributed to the integument on the back of the leg and heel. The *internal plantar nerve* branch seeks the sole of the foot, and lies between the *abductor pollicis* and the *flexor brevis digitorum* muscles; but at the metatarsal bones it divides into three branches. *One* supplies the adjoining sides of the great and second toe; the *second* supplies the adjoining sides of the second and third toe; and the *third*, the corresponding sides of the third and fourth toes. This order is the same precisely as we observed in the hand by the digi-

Fig. 80. A View of the Posterior Tibial Nerve in the Back of the Leg.

1, 2. Indicates its course and its Branches, the upper part of the Peroneal Nerve being seen to the right.

tal branches of the median nerve. The plantar nerves supply the integument along the inner sole and side of the foot, also the articulations of the tarsal and metatarsal bones. The *external plantar* branch gives nervelets to the integument along the outer border and sole of the foot, and then sends forward two digital branches to supply the little toe and one side of the next toe.

The *peroneal nerve*, we know, is one of the principal terminal branches of the great ischiatic nerve, the *popliteal* and *posterior tibial* being the other forks. And this bifurcation, we know, takes place above the popliteal space. This nerve passes outward and downward by the side of the inner hamstring, or tendon of the biceps, crossing the inner head of the *gastrocnemius*, and the origin of the *soleus*, to the neck of the *fibula*, and there emerges from under the origin of the *peroneus longus* muscle, and then divides into the *anterior tibial* and the *musculo-cutaneous*. From the peroneal nerve there is first the *communicans peronei*, which crosses over the external head of the *gastrocnemius* to the middle of the leg. It then sends a large branch to unite with a large branch from the communicans *poplitei*, and so constitutes the *external saphenous* nerve; it then descends to the external ankle, to which, and to the integument of the heel, it distributes nervelets.

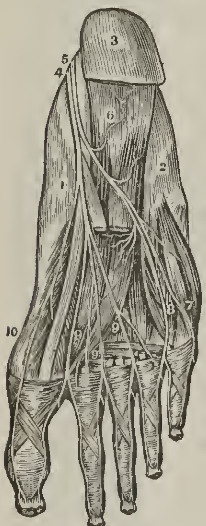


Fig. 81. A View of the Termination of the Posterior Tibial Nerve in the Sole of the Foot.

The *cutaneous* branch of the peroneal

1. Inside of the Foot.
2. Outside of the Foot.
3. The Heel.
4. Internal Plantar Nerve.
5. External Plantar Nerve.
6. Branch to the Flexor Brevis Muscle.
7. Branch to the outside of the Little Toe.
8. Branch to the space between the Fourth and Fifth Toes.
9, 9, 9. Digital Branches to the remaining spaces.
10. Branch to the internal side of the Great Toe.

nerve passes down the outer side of the leg, supplying the skin and fascia on its way to the dorsum of the foot, where it ramifies the integuments as its ultimate distribution. The *anterior tibial nerve* branch passes down beneath the *extensor communis digitorum*, passes under the annular ligament at the instep, supplies the adjoining sides of the great and second toes; it also gives twigs to the *interossei* muscles on the outer dorsum of the foot, and to the articulations of the *tarsus* and *metatarsus*. The *musculo-cutaneous* branch (mark !) passes down over the *fibula* in the substance of the *peroneus longus* muscle, but at the lower third of the leg it emerges, and branches superficially; one of these goes to the top of the foot, and then to the toes, passing in front of the outer ankle bone. In fact, this branch divides on the top of the foot; one branch then subdivides, to supply three and a half toes, and the other branch one and a half.

Now, to sum up what we learn from clinical experience, as well as from anatomy, and by comparing, we find in this region the *neuralgic spots* to be, first, at the exit and ultimate ramification of the *nervi glutei* on the side of the hip, and where many lumbar branches also terminate, which pain is very often mistaken for rheumatism, or some affection seated in the great sciatic nerve trunk. Next, a *neuralgic spot* is found *about the tuberosity of the ischium.* Next, is the most remarkable *neuralgic spot* of all, which is *about half way between the ischium and the trochanter major; and this point*, we know, *is over the emerging spot of the great ischiatic nerve trunk, and is the more usual*

Fig. 82. A View of the Anterior Tibial Nerve.

1. The *Peroneal* Nerve, a Branch of the Ischiatic. 2, 3. The Anterior Tibial Nerve, accompanying the Anterior Tibial Artery down the Leg, and on the Foot.

seat of all sciatic tenderness and pains. Next, we find a *neuralgic point* over the course of the *middle posterior cutaneous nerve trunk*, and also *in the popliteal space* where it is distributed; a *neuralgic spot* at the external condyle of the femur; a *neuralgic spot over the course of the popliteal nerve*, and another at its termination. Another *neuralgic spot* is found over the superficial trunk of the *external saphenous nerve*, on the middle calf of the leg, and along the outer border of the tendo-Achillis, and at the root of the little toe. Another *neuralgic* spot is some two inches below the knee joint, on the outer aspect of the leg, *where the peroneal nerve trunk emerges* to become superficial; and another spot at the outer ankle joint and heel, where it terminates. And finally, we find a *neuralgic* (and gouty?) *spot* at the terminal twigs of the great sciatic nerve, through the anterior tibial, which we know is mostly on the big toe.

Now, if we examine the *anterior* aspect of the lower limb, we find the first and most frequently *neuralgic spot immediately under Poupart's ligament, where the femoral nerve trunk emerges, and there becomes superficial.* So, indeed, is all the anterior and inner part of the thigh very prone to neuralgic pains, because the femoral or sacral nerve is superficial, and throws nearly all its ultimate ramification of nervelets into the integument over this space from the groin to below the knee, but particularly over the inner condyle of the knee, over the middle of the *sartorius* and *rectus femoris* muscles, also *just below the knee-pan.* Next, we often find a *neuralgic spot over the exit of the short saphenous nerve*, along the inner border of the sartorius muscle; then again *over the long saphenous nerve*, but more particularly at its termination *along the inner ankle, and about the inner side of the great joint of the big toe.* And finally, we find liable to neuralgia *the spot of emergence* of the *cutaneous branch of the internal saphenous nerve, which is about the middle of the thigh*, and where many other nerves also become superficial; and another *spot* might be mentioned, and that is, *the ankle joint.* This may be doubted by some, as pains here are usually referred to sprain or rheumatism;

but we must recollect that in and about this articulation are spent the ultimate ramifications of many nerve twigs, but especially those of the *internal saphenous nerve*. (See p. 476.)

CHAPTER VII.

ANÆSTHESIA — DIMINISHED NERVE ACTION AND PARALYSIS.

General Palsy.

When all the limbs, as well as the body, of an individual are deprived of motion, the affection is viewed as a *general palsy*. I have seen a case of catalepsy similate this; but then the sphincters were *un*affected, and the case remained in this state for but a short time. *General* palsy, strictly so speaking, may occur as a merely extended state of paraplegia. In these rare cases, voluntary motion alone may be lost, while sensibility still remains; so may both be lost, but such cases are extremely rare. The origin of this sad condition is, probably, from some lesion of the spinal cord, or its membranes, situated high up, still *necessarily* below the origin of the pneumogastric nerves. Some general, special poison, as the *worara*, might cause it. Sir Benjamin Brodie very justly remarks that it is not to be supposed that *fatal* cases of palsy are always mere "functional diseases, simply *because we cannot find a lesion after death*. The mysterious and minute organization of the brain and spinal cord is by no means to be freely inspected by the naked eye. Nor even by the aid of a microscope can we trace but a little way. Some change of ultimate structure, some grand defect in the minute and intricate *ensemble* may exist, and yet be far too fine and deep to be perceptible to our coarse senses." (See pp. 476–479, and App. B, C.)

Muscles of the Body, Anterior View. Fig. 83.

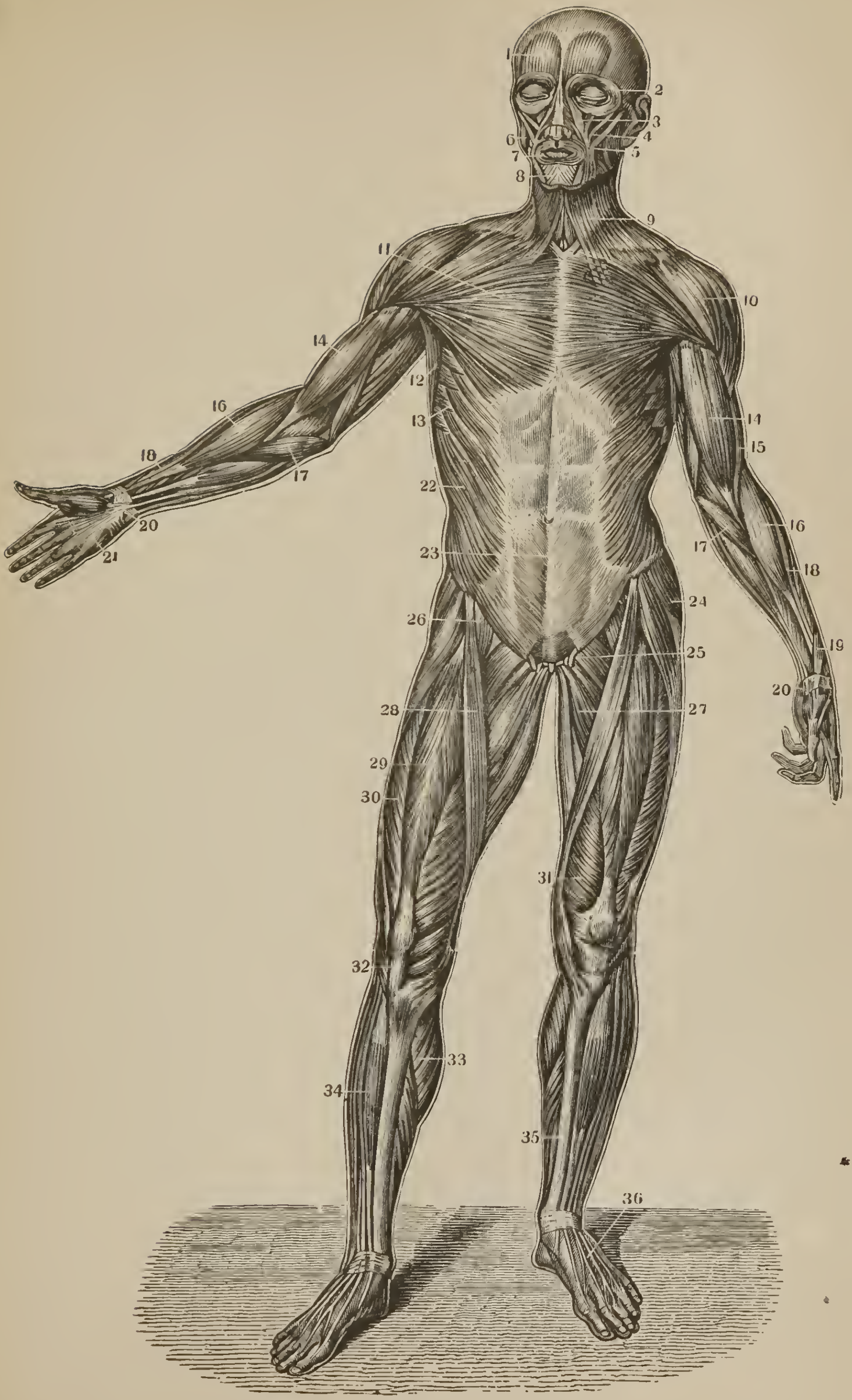
(See opposite page.)

1. Frontal Portion of the Occipito-Frontalis.
2. Orbicularis Palpebrarum.
3. Levator Labii Superioris Alæque Nasi.
4. Zygomaticus Minor.
5. Zygomaticus Major.
6. Masseter.
7. Orbicularis Oris.
8. Depressor Labii Inferioris.
9. Platysma-Myoides.
10. Deltoid.
11. Pectoralis Major.
12. Axillary Portion of the Latissimus Dorsi.
13. Serratus Major Anticus.
14. Biceps Flexor Cubiti.
15. Anterior Portion of the Triceps Extensor Cubiti.
16. Supinator Radii Longus.
17. Pronator Radii Teres.
18. Extensor Carpi Radialis Longior.
19. Extensor Ossis Metacarpi Pollicis.
20. Annular Ligament at Wrist and Instep.
21. Palmar Fascia.
22. Obliquus Externus Abdominis.
23. Linea Alba.
24. Tensor Vaginæ Femoris.
25. Section of the Spermatic Cord.
26. Psoas Magnus Muscle.
27. Adductor Longus.
28. Sartorius.
29. Rectus Femoris.
30. Vastus Externus.
31. Vastus Internus.
32. Tendon Patellæ.
33. Gastrocnemius.
34. Tibialis Anticus.
35. Tibia.
36. Tendon of the Extensor Communis.

Muscles of the Body, Posterior View. Fig. 84.

(See page 474.)

1. Temporalis.
2. Occipital Portion of the Occipito-Frontalis.
3. Complexus.
4. Splenius.
5. Masseter.
6. Sterno-Cleido-Mastoideus.
7. Trapezius.
8. Deltoid.
9. Infra-Spinatus.
10. Triceps Extensor.
11. Teres Minor.
12. Teres Major.
13. Tendinous Portion of the Triceps.
14. Anterior Edge of the Triceps.
15. Supinator Radii Longus.
16. Pronator Radii Teres.
17. Extensor Communis Digitorum.
18. Extensor Ossis Metacarpi Pollicis.
19. Extensor Communis Digitorum Tendons.
20. Elecranon, and Insertion of the Triceps.
21. Extensor Carpi Ulnaris.
22. Auricularis.
23. Extensor Communis.
24. Latissimus Dorsi.
25. Its Tendinous Origin.
26. Posterior Part of the Obliquus Externus.
27. Gluteus Medius.
28. Gluteus Magnus.
29. Biceps Flexor Cruris.
30. Semi-Tendinosis.
31. } Gastrocnemius.
32. }
33. Tendo Achillis.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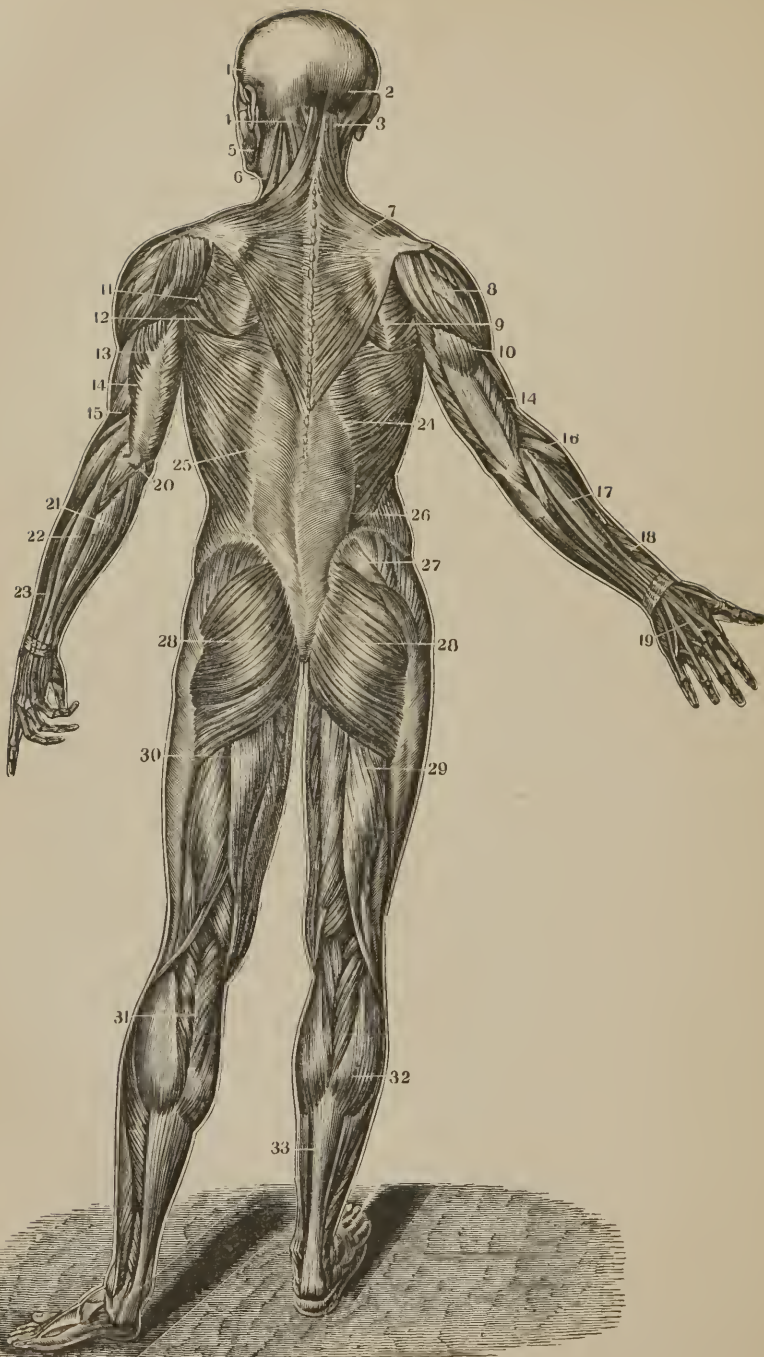

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Directions for the Electric Sitting, or Seance.

A. NOTE 1. (See page 280, also *notes* in Appendix.) These explanatory notes are introduced here to facilitate others, less experienced, in the employment of electricity, by making very plain some of the *minutiæ* of the author's *method*, (in sitting the patient, in managing the electrodes, and guiding the current, as *by a law*,) during each of the different *orders* of sittings instituted by him for the different classes of diseases appropriately so treated, and for such found most uniformly successful. The *systematic rules* here laid down for employing electricity as a remedy, although not found elsewhere in this or in any other language, are not the mere idea of a theory, but are the apparently well-corroborated results of the author's own clinical experience. The word "*seance*" means the same as if we should say, "a sitting for electric treatment." In my office — since this has been and is with me *a special practice* — we have four different orders of attitudes for the "*seance*," (as it is termed by the French,) and for these we employ, —

1. The *insulated* chair and stool.
2. The cushioned *ottoman*, covered with rubber cloth.
3. The *invalid's chair*, with a head-rest.
4. The *lounge*, with pillows, &c.

To prepare a person on the first *order* of sittings, the clothes need to be tucked up from the floor, &c., so as to *insulate* the patient as perfectly as possible.

To prepare for the second *order*, the object is, *to get free access to the whole back, thorax, and abdomen.* If the patient is a boy or man, let him merely unbutton his clothes, and thus take his seat upon the ottoman, stool, or a chair turned sidewise, with his back towards the operator, his shirt and under flannel pulled up above the waistbands; while the latter takes his seat on a low stool behind the patient, with his table of apparatus close by, at his right hand. In this arrangement he can freely manœuvre the electrodes, up or down the whole back, side muscles, thorax, abdomen, loins, hips, &c. If the patient be a female, let her lift or gather up the back part of her skirts, as she is about to take the seat; the corsets and dress are to be loosened, and thus the hand of the operator can be passed freely up the back, or from the neck downwards; so also over the sides, chest, muscles, abdomen, and loins, as the case may require, — *without removing the clothing.* In this attitude we also have easy access for adjusting one of the electrodes under the nates, coccyx, Poupart's ligament, or on the lumbar region, while operating on the nerves and muscles of the thighs and lower limbs with the other electrode.

The *reclining chair*, or rocking chair, receives the patient for the third order, and is used for all operations about the face, eyes, ears, head, throat, &c.

The *lounge*, or sofa, or cot, is the fourth order, and is desirable for a variety

of cases, such as where there is a contracted hip joint; so also for some affections of back, rectum, bladder, uterus, &c. (See pages 280, 328, 430.)

A. Note 2. A very small intensity current, such as that produced by the Humboldt battery, may be maintained *continuously* during the night, or even for days, with happy effects. So also the compound primary current of a Garratt's battery may be applied for 5, 10, 15, 30, or 40 minutes at a time, and even for an hour or so, as in tetanus and convulsions, provided the *power-coils* are proportionally few, or the application is not near or about the head. But the powerful primary current of *both quantity and intensity*, such as produced by a Daniell's or a Smee's battery, has so much *chemical* effect in living tissues, that — although perfectly safe, and highly useful, when applied for given cases, and by a precise *method*, for only a fraction of a minute — we must ever be reminded that *the long-continued application of such a current to the human organism is not safe, and is not its correct or philosophic use*, but in all the minute details of *current direction*, whether this way or that, applies equally well for all the primary galvanic currents, as for all the secondary or Faradaic currents.

B. Note 1. Experience leads me, of late, to conduct the electric treatment for most of the cases of neuralgia, rheumatism, "*sciatica*," and other *pain-causing conditions* of the nerves, muscles, and joints of the "lower limbs," — i. e. such as are not inflammatory, — under one of two general rules: —

Rule 1. *For Pains in the Lower Limbs.* (See page 360.) — Where the painful limb is *cold* and soft, or lean, and with poor circulation, and particularly if the pain, stiffness, and weakness is about the hip and thigh, and mostly or *only above* or *about* the knee joint, — the foot and ankle being weak, — in all such cases apply the current in a *direct* or *down-running* direction; always observing, in these cases, one other of my rules for neuralgic affections, viz.: to commence the application with the utmost caution and gentleness in every possible respect; also using only large, fine, soft, and moist sponge electrodes, (see pages 328, 329,) one of which (the *positive*) is to be placed, according to the nature of the case, over the exit of the great sciatic nerve, or under the coccyx, or a little above the second lumbar vertebra, or else *occasionally glided* from the one place to the other, searching for the most tender spots, over and about which, when found, this electrode is to linger; and at the same time applying the other (*negative*) sponge into the popliteal space back of the knee joint, where it is to be held for, say, 30 or 60 seconds, with a gradually increasing current; then gliding it along, so as not to interrupt the current, on to the external *peroneal* nerve trunk, in like manner; then move it along over the *extensor digitorum* with a full bearable current; then wiping it over the whole calf of the leg for a minute or so more; then on to and about the outer ankle joint, and so on to the roots of the toes, first above, then underneath, but without once intermitting or reversing the current. Here let this electrode rest; and now commence gliding the other, upper (*positive*) elec-

trode downwards, from stage to stage, mostly following, and pressing it over, the course of the affected nerves, but also wiping it over the muscles of the thigh, and about the knee joint, on its way down, terminating the *seance* by working the sponge down to the ankle. If there is *arthritic rheumatism*, then pass a strong current also *through* the affected joint, in a direction downwards and outwards, and so maintain it for some minutes. If, however, the pain, soreness, weakness, or contraction is rather on the anterior and inner side of the thigh, then proceed as before ; but, *from* the abdominal ring, crest of ilium, or exit of the great femoro-crural nerve, *to* the inner side of knee joint, for some time; then to the inner calf of leg, ankle joint, and inner edge of foot. Carry out these principles in all similar cases. If the case is a mixed one, or is not benefited by some three, or four, or half a dozen sittings, then try, or pursue the plan laid down in the next rule; but observe only the one rule or the other throughout any one seance.

Rule 2. *For Pains in the Lower Limbs.*—When the painful limb is plump, solid, and *warm*, i. e., when the tissues appear to be well nourished, particularly if the pains occur mostly or *exclusively below* the knee or ankle, or along the calf of the leg, or in the foot,—then, for the most of such cases, in order to be successful, we are obliged to apply the electric current, during the seance, in an *inverse* or *up-running* direction; always observing the same precautions, and usually first trying the method laid down in the foregoing rule. For these cases we must, therefore, plant the *positive* sponge electrode at the root of the toes, while the *negative* is at the same time directed to the external *peroneal* nerve, or inner condyle of the knee, or popliteal space; and so gliding it on over the *vastus externus*, and *gluteus*, to the great *sciatic* nerve trunk, or to the lumbar region; or else over the *rectus femoris* and *adductors*, to the *crural* nerve trunk, and from there to the lumbar region. Thus, at one of these places, let this *negative* electrode now rest; while, with the other, we proceed to work gently upwards, from half minute to half minute, from the foot, over the ankle, to the knee, and so on over the thigh muscles; and while here, the *negative* should be removed to, if not already at, the lumbar region, while the *seance* is being finished, by working the *positive* up to the groin, or ischiatic notch, and there retaining it a little; the whole occupying 5, 10, or 15 minutes. Let this be repeated daily, or every other day, until the patient is quite restored.

Rule 3. *For Pains in the Upper Limbs.* (See page 454.)—Neuralgia, rheumatism, and other *pain-causing conditions* of the nerves, muscles, and joints of the shoulder, arm, and hand, must be treated much on the same principle as already laid down, under two *rules*, for sciatica, &c., (for which see at B., Rule 1.) If, therefore, the case presents a painful shoulder or arm, that is *cold* and soft, or lean, particularly if the pain or lameness is *mostly* or *entirely* about the shoulder, upper arm, or elbow, in such a case apply the current in a "*direct*" or *down-running* direction. First, plant the *positive* sponge electrode on the cervical spine, while the *negative* is being directed over the

brachial plexus for a minute; then glide it along down the *pectoral* muscle to its farthest extent; then over the *median* or the *ulnar nerve*, near the elbow joint; then glide it along down the outer side of the fore-arm, to the back of the hand but a little below the wrist joint; then wipe it over the extensor muscles on the back of the fore-arm; and then in like manner over the flexors. Next allow this *negative* sponge to rest a little first in the palm of that hand, and then on the back of that wrist joint; and at the same time commence moving the upper or *positive* sponge that has been on the upper back, and with it bathe over all the shoulder, neck, and pectoral muscles, and then also those of the arm, down to the elbow, and particularly over the trunks of the median, ulnar, and circumflex nerves; and so finishing the *seance* by working the electrode down below the elbow joint on the fore-arm, while the other is still at that hand. If there is a *rheumatic* affection of the joint of the shoulder, elbow, or wrist, then pass a smart current *also through the affected joint* transversely, or rather obliquely, and mainly downward and outwards, for some few minutes more at each *seance*.

RULE 4. *For Pains in the Upper Limbs.*—If the patient presents a painful arm that is plump, firm, and *warm*, with good circulation, and more especially if the pain or lameness is *below* the elbow, and about the wrist or hand, then for such like cases, if the previous rule has been tried and failed, then apply the current in an *inverse* or *up-running* direction; always bearing in mind my fundamental *neuralgic rule* regarding careful manipulation. Commence this *seance* by first planting the *positive* electrode over the *median* or *ulnar* nerve, near the elbow; then, with the *negative* sponge, commence bathing with electricity over the *deltoid*, the *biceps*, and *triceps*, and so on to the *pectoralis*, and then lingering for a minute over and about the *brachial plexus*; next wipe it over the shoulder muscles, and then let this (negative) sponge rest, or be moved a little about (not above) *the upper dorsal of the spine*, and at the same time gliding the *positive* sponge along from half minute to half minute, first about the elbow, then over the fore-arm, wrist, and hand, and then back again up the arm, from stage to stage, until it sweeps over, not only the whole arm, but also the pectoral muscles; and after lingering a minute, or so, under and above the clavicle, glide it upwards and backwards until it rests just back of the shoulder joint; then start the negative from the dorsal spine, and with it bathe over the lower spine with a stronger current; then also the *infra-spinatus*, *teres*, and *seratus magnus* muscles; thus following the course of those brother twigs of arm nerves which are distributed over the ribs on the side and lower front of the thorax. Thus ends this *seance*.

C. *Rules for Paralysis in any of the Limbs.* (See page 471.)—Now, since we know those *fundamental laws in electro-physiology*, viz., that when the electrodes, with any form of electricity, are so applied to any portion of the *living* human organism that the current is direct, (down-running,) then the effect thus produced is *a modified polarity of the nerves and muscles so embraced*; also a *less nervous action*, or at least *less "abnormal"* nervous action, is obtained in the parts *at*, *about*, and *above* the *positive* electrode, while there is an *increased nervous action at*, *about*, and *beyond the negative* pole; and that if the direction of this current be reversed, i. e., so as to be *inverse*, (up-running,) then the results will be precisely the same, but in a reversed order also; i. e., *diminished* action below, and *increased* action above; moreover, that this effect is greatly increased, if the current, in whichever way directed, is now and then *suddenly* interrupted, if for only a moment at a time; and that all this is still further increased in effect, i. e., far more extensively and profoundly disturbing and impressing the embraced nerves, if not the whole nervous system, by *suddenly and repeatedly reversing the current*,

as well as interrupting it, and that in direct ratio to the intensity of the electric current so employed, and inversely to the want of susceptibility in the organism, or hinderance to the inworking of the current. Therefore, these being facts, for paralysis we are to direct one electrode — whether moist sponge, or metallic plate or ball, covered with wet cloth or buckskin — to the fleshy part of the affected muscle or muscles, while the other is planted over the large nerve, whose branches ramify that muscle, and thus run the current in a *direct* manner, from quarter minute to quarter minute. Let the *breaking* of the current be *suddenly* done, at the *switch*, or binding screw, and not by lifting off the electrode from the skin. So let the *reversing* of the current be done by the *switch*, or by exchanging the *contacts* with the electro-magnetic machine, or by the *key-board* of the galvanic battery,—i. e. metallic,—and not by exchanging the electrodes. Thus, for a few minutes, work up the polar molecular mobility of the affected nerves and muscles, and then for a few minutes resort to Faradaizing, not only the sick nerves and muscle, but also those adjoining, or even the whole limb; and thus alternately operating, more or less long and severe, at each *seance*, according to the strength of the patient and the effects produced. When we still suspect or fear EXISTING central disease and source of the malady, (although in doubt, or even hoping to find a better state,) then we must *not* resort to any *reversings* of the current, nor even to *sudden* intermittences; at least not to risk this until after trying several applications *on general vitalizing principles;* such, for instance, as laid down for hysteria, and for atony of the abdominal viscera, &c., (for which see F., in Appendix.)

Thus we can operate on a case so as not to disturb very much the central organs, i. e., the *brain* and *spinal marrow*, (while at the same time we do thus most profoundly modify the ganglionic centres,) by employing gentle and moderate *direct* currents, as under *neuralgic rules;* but we make somewhat more effect if we *suddenly interrupt* the current, or twitch the muscles by it; and we make more *central* effect still if we also *reverse* that current, and still greater effect if the current is directed considerable of the time *towards the head*, particularly if the *negative* electrode is about the neck, or *near the head;* and the effect is heightened still more if such a current is occasionally interrupted and reversed for a little, but *maintained mostly in the up-running direction;* and the profundity of every such impression is, moreover, in direct ratio to the strength of the electric current employed.

If, therefore, any portion of the arm or hand is paralyzed, we must first place the *negative* electrode on the *brachial plexus*, or nerve *medianus*, and with the *positive* work a strong current over the neck, cervical and dorsal back, as well as over the pectoral and shoulder muscles, for a few minutes, and then, placing the *positive* stationary on the plexus or nerve, proceed with the *negative* to make such oblique passes and such interruptions and reverses of the current over the affected muscles as will bring them into full action. This may be followed up by Faradaization, at the same *seance*, with good effects.

If any portion of the leg or foot is paralyzed, we must first place the negative electrode over the exit of the ischiatic nerve, or over the femoro-crural nerve, (according to the affection,) and with the *positive* proceed to bathe electricity over the whole spine, back muscles, and bowels, using a smart electric current. After this, place the *positive* electrode stationary at one of those great nerves, and with the *negative* make such oblique passes and current reverses over the fleshy parts of the sick muscles as to cause them to freely contract; but always aim to bring this about with the least possible pain.

Paralysis.

The term "Paralysis," or "Palsy," (which mean the same,) is used to designate some degree of *loss of the power of motion.* There is, likewise, a paralysis of *sensation;* but this is termed "Anæsthesia," and will be treated of under that head. A loss of both sensation and motion frequently occurs together; but the paralysis of sentient nerves is more likely to be recovered from early, than the paralysis of motor nerves. They may not only occur together, but either may appear without the other; but then even, the simple paralysis of sensation (anæsthesia) is far more uniformly and promptly recovered from spontaneously, or by the help of treatment, than is the idiopathic or traumatic palsy of motor nerve and muscle fibre, which constitutes what we usually understand by the term *paralysis.* But we must ever bear in mind that palsy, like pain, *is but a symptom*, and not the essential disease itself. Says Dr. Todd,* "Non-medical people, and sometimes even medical men, are apt to speak of this affair as if the palsy constituted the whole essence of the malady; but this is not the case. Palsy is an effect due to a cause, which cause itself is not always the essential disease." This is also true of most other diseases. "What then," he asks, "are the causes which may give rise to paralysis? These must be, either an affection of the nerve or nerves, whose power is destroyed in some part of their course; or from a morbid state of the *centre*, in which the given nerve or nerves are *implanted*, or with which they may be more or less directly connected. The nervous trunks themselves may be impaired, perhaps, in their nutrition, the centre being healthy; or they may have suffered some mechanical injury from violence or pressure. Thus they may become either *imperfect conductors* of the nervous message and force, or they may be rendered altogether incapable of *propagating* that force, or some portion of the *centre of volition* is the seat of a morbid process whereby the influence of the 'will' over certain parts is suspended, and thus the nerves of these

* Clinical Lectures on Paralysis, Diseases of the Brain, &c., London, 1855.

parts receive no impulse at all from that centre, whether mental or physical; and although those parts may still be perfectly healthy in themselves, yet are they thus incapable of taking part in voluntary acts. (See p. 242 and Notes on p. 477.)

"Furthermore, whatever interferes materially with the *conducting* power of nerve-fibre, or the *generating* power of nerve vesicle, (gray matter,) will constitute a paralyzing lesion. In the first place, *poisoning* of the nervous matter will operate in this way: For instance, soak a portion of the nerve of a living animal in chloroform, or ether, or opium, and that nerve will fail to propagate the normal nervous force as long as the influence of the poison lasts. In a similar way, the poison of lead in the human system may paralyze, either by weakening the conducting or the generating power of the nervous matter. Poisons *formed in the living system* may operate in the same way; such as retained urinary or biliary principles, or the poisons of rheumatism, gout, &c.

"Secondly, any *morbid process* which greatly impairs the natural structure of nerve matter will paralyze. Thus inflammation will do this; so also will atrophy, or wasting from want of sufficient supplies of nutrient matter, as where the flow of blood is lessened, or cut off. The opposite conditions of *hardening*, and so of red or white *softening*, of the nervous matter become paralyzing lesions from the same reason, viz., that they greatly impair or destroy the nerve structure.

"Thirdly, a *solution of continuity* of nerve fibre will paralyze. Cut a nerve across, and you have immediate palsy of the parts which the nerve supplies below the section. This solution of continuity from a final melting down of the fibres is, I have no doubt, the more frequent cause of sudden paralysis in cases of softening, or in cases of sanguineous effusion.

"Fourthly, *pressure* on a nerve or nervous centre will paralyze. Of this we have many proofs as regards nerves. A nerve, as for instance, included by a ligature, or compressed by a tumor, is paralyzed thereby. A fracture of the skull, *with depressed bone*, will paralyze, if the brain is sufficiently compressed. An apoplectic clot on the exterior of the brain paralyzes by compression;

so also if a tumor is in its substance. It is by compression, probably, that congestion paralyzes; *but this latter cannot often* be regarded as a true paralyzing lesion.

"I would say here, that the *centre of volition* (the *seat* of the *will*) is of very great extent; for we know it reaches from the *corpora striata* in the brain, down the entire length of the anterior horns of the gray matter of the spinal cord, and includes the *locus niger* in the *crus cerebri*, as also much of the vesicular matter of the *mesocephale* and of the *medulla oblongata*. Disease of or accident to any part of this nerve centre is capable of producing paralysis of voluntary motion; but as the intra-cranial portion of it exercises by far the greatest and most extended influence in the production of voluntary movements, so disease of *this portion* of nervous centre gives rise to the most extended and complete paralysis.

"Another fact, to be borne in mind, which anatomy demonstrates and pathological research confirms, is, that *the centre of volition* for either side of the body is not altogether on the same side of the body. Of the nerve centre for the left side of the body, for instance, the intra-cranial portion is on the right side, while the intra-spinal portion is on the left side; and these two portions are brought into connection with each other through certain oblique fibres from the *anterior pyramidal columns* of the *medulla oblongata* which cross from right to left, decussating with similar fibres proceeding from left to right, and which belong to the centre of volition for the right side of the body." Thus much is demonstrated.

While studying and treating the diseases of the nervous system, we shall do well to keep definitely before our minds the several leading propositions of recent systematic writers. We know that Dr. Marshall Hall lays down the hypothesis of an "*excito-motory system of nerves*," *and of a true spinal cord;* that is, as the centre of all physical nervous action. The various muscles and sentient surfaces of the body are, according to him, connected with the brain directly by nerve fibres which pass completely from one to the other. Those fibres destined for, or proceeding from, the trunk to the brain, pass along the spinal

cord; so the cord is, in great part, according to him, no more than a bundle of nerve fibres, going to and from the brain, and these fibrils are specially for sensation and volition. And in addition to these, there is another class of nerve fibrils, according to Dr. Hall, proper to the spinal cord and its intracranial continuation, and which forms a connection with the gray matter of the cord. Of these fibres, some are afferent or "incident," while others are efferent or "reflex;" and these two kinds of nerves have an immediate, but unknown, relation to each other, so that each afferent has its proper efferent one, the former being the *excitor*, and the latter the *motor*. Now, the aggregate of all these fibres, together with the gray matter, says Dr. Hall, constitutes the *true spinal cord;* which, however, is not limited to the spinal canal, but passes up into the cranium as far as the *crura cerebri*. Moreover, these excitor and motor fibres are quite independent of those of sensation and volition, and of the *sensorium commune*, using that term as indicating the centre of intellectual actions, (as put forth by Prochaska.) Although these are bound up with sensitive and motor fibrils, yet they are not directly affected by them; and they maintain their respective course in the nerve trunks as well as in the centres. But this hypothesis of Marshall Hall is not entirely accepted now as complete.

Another grand hypothesis, as laid down by Müller, Whytt, and other leading physiologists of the present day, is, that the nerve fibres of sensation and of volition, individually and immediately, proceed to and from some part, or parts, of the intracranial nervous mass, and that every nerve fibril in all the organism is precisely by itself continuous into the brain. Those which are distributed to the trunk, or extremities, pass along the spinal cord, and separate from it at the various roots of the nerves, as they leave the spine; and while in their course within the spine they mingle more or less with the vesicular matter of the cord. According to this hypothesis, there are no other nerve fibrils but these, (excepting the commissural,) and they are quite sufficient to manifest all the physical, as well as the mental, acts. Thus the nerves of sen-

sation are capable of exciting the nerves of motion, which are in their neighborhood; and they may produce this effect, even, when the spinal cord has been severed from the brain; because their relation to the gray matter of the cord is such that their state of excitement, however varied, is readily extended to it. Neither is this hypothesis accepted in full, as such.

There is still another and more recent hypothesis put forth by Drs. Todd and Bowman, of London, which assumes that all the spinal and encephalic nerves, of whatever function, are *implanted in the gray matter of the segments of the cerebro-spinal centre*, with which they are severally connected, and *do not pass beyond.* The several segments of the cerebro-spinal axis are connected with each other through the continuity of the gray matter from one to another, and through the medium of *commissural fibres*, which pass between them. Motor or sensitive impulses, through these means, may be propagated from segment to segment; and a stimulus conveyed to any segment from the periphery may either simultaneously affect the train, and cause a sensation, or it may be reflected upon the motor nerves of that particular segment, and stimulate their depending muscles to contract. Or, indeed, both these effects may take place at the same moment, as the result of one and the same stimulus. According to these gentlemen, each segment of the cord, so long as it retains its proper *commissural* connection with the brain, (by both commissural fibres and continuous gray matter,) is in fact, and effect, part and parcel of the centre of volition, as well as that of sensation; and the mind is as directly associated with each segment of the cord as it is with any portion of the encephalon. Just let that commissural connection be dissolved or severed, and the mind will immediately lose its hold upon the cord and its dependencies. But the various segments of that organ may, nevertheless, be acted upon still *by physical impulses*, and may still continue to evolve the nervous force in connection with the natural changes which may take place within.

An abstruse writer in the British and Foreign Medico-Chirurgical Review, remarks that the recent discovery of Mr. Grainger, viz., that from each root of a spinal nerve some fibrils are

implanted into the gray substance of the cord, while others apparently become continuous with the longitudinal fibres of the cord, gives an argument in favor of the views of Dr. M. Hall. Moreover, it is distinctly understood that many anatomists still hold to the belief that some of the fibrils in each nerve root are continuous with the longitudinal fibrils of the cord; yet this by no means is evidence that they actually pass along the cord for any great portion of its length, far less that they pass upwards continuously to the gray matter of the cerebrum. Besides, there is a general agreement that the great bulk of the fibres which constitute the *roots* of the nerves of any segment of the spinal centre, are implanted in the gray matter of that segment, and do not pass beyond it. It is now shown, also, that the white matter of the cord does not increase in amount from below upwards, as it ought to do according to Dr. M. Hall's views, but is, in truth, greatest where there is the most ganglionic enlargement.

These facts seem to justify, he goes on to say, after referring to the views of Todd and Bowman, that the spinal cord is the *chief* centre for the roots of the spinal nerves; that a considerable portion of the white strands of the cord is composed of fibres which are passing only a little way up or down the spinal cord, so as to reach segments of its own ganglionic centre, a few removes from the point at which the nerves join the cord; and that but very few, if any, strands or fibrils pass continuously between the roots of the nerves and the encephalic centres. We are not disposed, however, to deny *utterly* the passage of some few such continuous fibres; indeed, it seems highly probable, although not actually demonstrated, that some few do so extend.

We notice another difficulty, arising from the doctrine of the "distinct and continuous nerve-fibre system," which has reference to the *emotional* actions. These actions were supposed by Marshall Hall to take place through the instrumentality of the true spinal fibres; but this doctrine was objected to, by Dr. Carpenter, on the grounds that emotional actions may, and do, take place in parts which are paralyzed as to the *will*. Dr. Carpenter considered, therefore, that the emotions can only be excited

through the sensations, and that chiefly through those of the *special* kind. He contended, finally, that we must recognize the existence of a *third class* of nerve fibres, having their special seat or centres in the ganglia of sense, and independent alike of the cerebral and of the spinal. Indeed, Dr. Copeland, as early as 1825, advanced the doctrine of a third class of nerves, which he conjectured to be *prolongations* of the ganglionic fibres, extending by such subtile ramifications into all parts of the body as to escape ocular demonstration, yet as evidently existing. Dr. Todd also recognizes the necessity of this extension of the theory of a "distinct and continuous nerve-fibre system," *if it be adopted at all;* but adds, "it is difficult to admit the existence of *three orders* of nerve fibrils in integument and muscle, which, to be effective, must all have the same relation to the elements of the muscles."

But if we now leave all these hypotheses, and look closely at demonstration, we see, concisely, two or three well-defined propositions, viz. : —

First, that the *brain*, or some part of it, is absolutely essential to the production of mental nervous actions ; or, in other words, the actions of volition and sensation cannot take place without the brain.

Second, that the *vesicular* (gray matter) is the true dynamic nervous matter, and that which is absolutely essential to, and the *source* of, the development of all nervous power in human beings.

Third, we conclude that the anatomy of the spinal cord (as we now understand it) teaches us to regard each segment of it as the centre of its own proper nerves ; all centripetal impressions being received in the first instance by it, and all motor impulses finally proceeding from it ; and, at the same time, the connections established through *commissural* strands between the different segments of the cord itself, and between the cord on the one hand, and the cerebrum and cerebellum on the other, the impressions first conveyed to the cord, are carried on to the sensorium so as to produce sensations ; whilst motor impulses originating in the cerebrum, are brought to act upon

the muscles, by being directed to the segment of the cord whence their nerves proceed. All muscular movements, whether reflex, emotional, or voluntary, *are immediately called into action* by the same class of sensory or efferent nerve fibres; moreover, the excitor or afferent fibres are at once in like manner the channels of the transmission of stimuli, which gives rise, in one instance, to *reflex* actions through the spinal cord, and of impressions, in another instance, that become sensations when transmitted to the sensorium. The mechanism, then, of a voluntary action in these parts that are supplied by spinal nerves would be the following:—

The impulse of volition, excited primarily in the brain, acts at the same time upon the gray matter of the cord, (through the fibres of the white substance of the brain, which radiate from the *thalami optici* and the *corpora striata*, or, according to Dr. Todd, simply through the strands of the *medulla oblongata*, especially the anterior pyramids,) and then from this gray matter of the cord, simultaneously upon the *anterior* roots of the nerves implanted in it. This gray matter, in virtue of its association with the brain by means of the fibres of the white substance of the brain, or the anterior pyramids, *becomes part and parcel of the organ of the "will,"* and therefore as distinctly amenable to acts of the mind, as that portion which is contained within the cranium. If we destroy the commissural connection with the brain through the pyramidal or white brain fibres, the spinal cord ceases to take part in or respond to mental nervous actions; or, if that connection be only *partially* destroyed, then precisely that portion of the cord, which the now injured nerve fibres had formerly associated with the brain, is no longer influenced by the mind.

Again, if the seat of volition in the brain be diseased, then the portion of the cord that corresponds to the seat of that lesion participates in the effects of the disease as far, at least, as regards *voluntary actions*. And again, we must bear in mind that a continuity of *fibrous* structure here is not absolutely necessary for the transmission of nervous energy, or, as Dr. Todd would say, "*for the excitement of nervous*

polarity," for there is ample evidence that the vesicular substance alone, here, may be subservient to this purpose. It has been fairly demonstrated, by Stilling, and Van Deen, "that both sensory and motor impressions can be communicated from one portion of the spinal cord to another, even after complete sections are made in such a manner as to leave the two portions of spinal cord only connected by the *gray* substance. In no other way, indeed, can we account for the *radiation* and multiplication of impressions in cases where there is a certain state of *exalted* (abnormal) polarity and activity of the "automatic" spinal centres.

"*Indolence* and *neglect of duty*," says Dr. George Johnson, "is a most prolific source of a class of serious and grievous nervous affections. This habitual want of doing, more often occasions *mental* disquietude, and unhappiness, than do even excessive labor and fatigue. Those who *habitually* 'kill time' are not unfrequently

> 'Haunted much by visions strange, —
> The spectres manifold of murdered hours;'

for the infringement of *moral laws* brings discomposure, unrest, and *anguish* upon the mind, just as surely as a physical injury gives pain to the body. Both these classes of pain and suffering, are protective and beneficial as well in their design as tendency."

Electro-Muscular Diagnosis.

Electro-muscular explorations, when carefully and understandingly performed, are very important *Diagnostic*, as well as *Prognostic* means now at the hand of physicians, to be employed in cases of paralysis that present either for treatment or simply to learn the prospects of a treatment. The loss of electro-muscular contractibility (when properly tested) enables us, first, to distinguish those paralyses that are due to an invisible or otherwise undiscoverable cause, — as, for instance, where there is a local, idiopathic, or traumatic lesion of the

nerves, — from those cases which are still depending upon a true cerebral origin and cause; for in this latter, the susceptibility of the palsied muscles to contract, when under the influence of Faradaic currents, remains *more or less intact;* while in the former, i. e., where the paralysis is purely from a local or traumatic lesion, this phenomenon is always utterly wanting.

And further, we find that the *gravity* of the given case of paralysis is in direct ratio to the loss of the electro-muscular *susceptibility* and *contractibility* of the muscles affected. But if this *muscular* "*sensibility*" is preserved, *or even partially so*, and that even where the electro-muscular *contraction* has become extinct, we learn that this great gravity is in some degree diminished, particularly if the neighboring muscles also show a *normal response* by electro-muscular contraction. This region integrity, where the case is not of too long standing, so that the sick muscle has not already passed by degeneration into a fatty state, is always a very favorable sign, at least as possible, or probable, that these muscles, under a judicious use of Galvanic or Faradaic currents, will rapidly recover. Moreover, we can now classify these cases even closer than this; but let us first notice the opinions of distinguished men upon this subject.

We observe that systematic writers arrange all those affections of the human organism that are designated as palsies, or paralyses, (which is the same thing,) under three general divisions, viz., 1. *Paralysis from brain origin.* 2. *Paralysis from spine origin.* 3. *Paralysis from traumatic lesion.* And under this last head are arranged all those cases arising from primary local effects upon the peripheric nerves, as well as those whose primary cause was perhaps from a brain lesion, (which is now restored,) and the remaining paralysis is only local.

The opinion of Dr. Duchenne upon this most grave question must certainly be considered. It has been declared by him, as also by Marshall Hall, Becquerel, and other physicians, that electro-muscular contractibility remains, or is exalted, in all those cases where the origin and cause are in the brain. That is, if Faradaic currents are localized in the affected muscles, or where one pole is placed on the muscle and the other is over

its nerve trunk, there can be produced visible contractions in the palsied muscle itself, which, however, will fall back into its helplessness as soon as this influence is withdrawn. Dr. Duchenne is of the opinion that all such cases as arise either from a lesion of the brain, or of the spinal marrow, *are by no means "necessarily" suitable cases to receive electrical treatments during the earlier stages*, —certainly not until after some six or eight months after the attack. But where the red or white softening, or the apoplectic clot, has not caused the person to sink under the immediate shock, but, on the other hand, the person has rallied, although slowly, and the clot has undergone resorption, and the hemorrhagic focus has cicatrized, or the softening has been restored, (either of which being manifested by the general appearance, history, and electro-muscular test,) no doubt in such favorable cases, judicious electrical treatments may be resorted to, not only with safety, but also with the greatest benefit. In some of the more favorable cases, we shall often find nature restoring in part, at least, some of the voluntary muscle movement, and this is another favorable omen. Dr. Duchenne declares, however, that in recent cases of paralysis, so long as the work of cicatrization of the damaged brain is not completely terminated, he finds the application of induction currents, (in the way he employs them,) as treatments for restoring motion and the power of the will, is not only useless, but may prove very hurtful. In fact, it has been frequently observed that from the too early resort to this active agent, and that perhaps in no kind of order, new cerebral hemorrhages are more apt to follow. He in another place says, however, that nothing is more variable than the duration of the time that is absolutely necessary to bring about cicatrization in each individual case; yet after a delay of some half year, more or less, we may employ Faradaization for those paralyzed muscles, whose electro-muscular contractility *has only been diminished by the prolonged inaction*, and severance from the influence and coöperation of the will.

Duchenne shows that for those muscles in which the prompt electro-muscular contractility has remained quite intact, such

muscles gain nothing from electrical treatments for their *voluntary* contractility, *if this power is lost* in whole, or in part even, as this loss of *voluntary* action, while there is prompt electro-muscular response, is not from the incapacity of the muscle to contract, as is thus proved, but it is from a want of functional continuity of communication with the organs of volition at the base of the brain. But in the former cases, where the paralysis seems to be mainly, if not entirely, *localized* in the muscles, and this diminished action is from inaction, then the employment of Faradaization of those muscles becomes highly useful, and often completely successful. (See pp. 331, 512–516, and F, Note 2.)

Even such results will not be happy, however obtained, except so long as the hemorrhagic focus, or other lesion, is nothing more than a healthy cicatrix; for if, after the resorption of the effusion, whatever that may be, if there remains a persistent clot, or debris of a clot, or a cyst of any size, or if the brain has suffered any considerable loss of substance, then even, also shall we realize a failure of the best electrical treatment.

On the whole, then, we infer from his reasoning, which is based, as we should bear in mind, on the earlier but most extensive experience in systematic electro-medical practice, that it is very difficult to determine in any exact manner the condition or degree of the lesion in the brain; but that some six months after the malady first showed itself, the paralysis being no longer *caused*, or, in other words, *sustained*, by the central lesion, and that under the above circumstances, and where there is no sort of rigidity which characterizes all such cases, it can then be safely treated by Faradaic currents, and that many of such will be greatly benefited, or completely restored. In proof of this he gives a variety of striking examples.

Furthermore, M. Duchenne lays down the *rule*, also observed by others, that the contractions of certain muscles and limbs following cerebral injuries are due to a *persistent irritation in the brain*, and that the proportion of this contraction is in direct ratio to the degree of the brain irritation. Hence, where there is *persistent* rigidity of a muscle, or group of muscles, electricity will do no possible good, but rather do harm. But

where the rigidity is *transitory*, he has found that electricity can cause it to diminish still more and more rapidly, if employed with prudence and skill.

It is scarcely necessary to mention in this connection, that where the state of lesion of the cerebro-spinal axis is evidently but the recent arrest of softening, or is the consequence of cerebral or spinal tumor, or of bony pressure, it is then invariably (when so fairly judged) best to *proscribe* absolutely any employment of electricity whatever. It certainly cannot be calculated to remove the cause, nor yet ordinarily in such cases ameliorate the temporary suffering. Dr. Duchenne, therefore, concludes, as the result of his great experience, that the electro-muscular contractility is always normal in cerebral paralysis; i. e., that there is no difference between the response of the muscles of the paralyzed limbs and those of the healthy; but this proposition, the author must say, is not entirely in accordance with his own observations while testing and treating such patients.

Marshall Hall, as well as Duchenne, believed that in true *brain* paralysis, the muscles remain intact; but on the contrary, that in paralysis arising from a *spinal* origin, the electro-muscular contractions entirely fail. But this last proposition, although defended by the former, is not fully corroborated by the latter; yet he allows that he does find, from lesions of the spinal cord, that muscular irritability *is diminished, and almost, if not quite, always so*, as he had often proved by testing with the currents the several affected muscles. But Duchenne found at least one fair exception; for, although there did exist such a lesion and cause, yet there was complete electro-contraction of the affected muscles. As the patient soon after died of a fever, the peculiar lesion was proved by an autopsy. There was found a complete disappearance of the gray substance on the median line in each of the two halves of the spinal marrow. But in all other cases where he could actually test the fact by an autopsy, he says he found a corresponding diminution of the electro-muscular contraction of the palsied muscles.

Duchenue lays down, moreover, as an important *rule*, that

whenever the application of electricity is indicated in the treatment of a case of paralysis consecutive to a cerebral hemorrhage, even if indicated in such a manner as seems positive, yet must we proceed to Faradaize the patient with the utmost precaution. It is necessary, he says, first of all, and indeed at all cost, to take care that the currents *do not pass from* the extremity that is acted upon, *to* the nervous centres, by directing the current so as to traverse the nerves in that direction of their length. For this reason it is his practice, in such cases, to bring the position of the electrodes upon the affected muscle, as nearly transversely, and as close together, as possible, so that the workings of the electro-magnetic currents may be confined within the touched muscles themselves.

As to the distinctive characteristics of the two great classes of cerebral and spinal paralysis, as manifested by the electric test, we find that M. Becquerel has studied them particularly. He comes to the conclusion, that there must necessarily be distinctions for particular cases. The degree or intensity of the susceptibility of a case to electro-muscular contractility is found to be about in proportion to the conservation of the power and ability of voluntary movements; i. e., in the muscles affected. So that this susceptibility disappears in an absolute manner, only, where the paralysis is complete, and where, at the same time, the voluntary movements are entirely abolished.

For all of this kind of cases, Dr. Becquerel advises the more simple kinds of treatments by Faradaic currents, and especially directs that each *seance* be short. But he does not so appear to dread the effects of reflex action from this procedure, but rather embraces the nerves in the current with this expectation.

The peculiar views of Dr. Marshall Hall, so important on this point, may be profitably rehearsed here. He gives as the result of his conclusions, that all kinds of muscular paralysis may be arranged, by the electro-muscular test, into two great classes — first, the Cerebral; second, the Spinal: this latter includes all local, peripheral, and traumatic cases. Thus he speaks: —

"I designate that paralysis as *cerebral*, in which, by whatever means or disease, the influence of the *brain* is severed; and I

designate that form of paralysis *spinal*, in which, from whatever cause, the influence of the spinal *marrow* is *severed*. It is unnecessary to state, that in the latter case the influence of the cerebrum is removed, as well as that of the spinal marrow.

"Before I proceed, I must take the opportunity of briefly alluding to the *functions* observed in the muscular system; for it is these that are variously affected in paralysis. The first function of the muscular system which I shall mention is *voluntary motion*, the *effect of volition:* the second function, or rather affection, of the muscular system, is the *effect of emotion;* the third is *reflex action;* the fourth is *the tone* of the muscular system; the fifth is the *irritability* of the muscular fibre. *All* these are wonderfully involved in every muscular act or action, though *one* may be principally so, and the affection of *each* becomes to the physiologist the source of diagnosis in cases of paralysis; for I may take this opportunity of stating, that *in the diseases of the nervous system, the electro-physiology is* the *diagnosis* of the case.

"I will briefly detail the particulars of two cases, which may be taken as *types* of the rest.

"The first was a case of hemiplegia, affecting the *right* side. The muscles of the right arm were paralytic, atrophied, contracted, and rigid. We placed *both* hands in one basin, containing water with a little salt, and the foot in another, and we passed a galvanic current through the limbs so disposed, beginning with the *smallest* force which would produce an obvious movement. Invariably, in many trials, the paralytic arm was moved by the slighter, but the most by a greater force, whatever the direction of the current.

"The second case was that of a little girl, aged two years and a half, in whom the left arm had been suddenly affected with complete paralysis nearly two years before; the head having at the time of the seizure been drawn to one side, and the child being under the influence of dentition. In this case, the paralysis of muscular power was, as I have stated, complete; the arm was atrophied, the muscles flaccid, the hand moving on the wrist, and if held in the dependent position, absolutely un-

controlled by muscular influence. We applied the galvanic *test* as before, using the *mildest* force which would produce an obvious effect. Now, the *unaffected* limb was first and most affected by the galvanism!

"In these two cases we have the marked forms of *cerebral* and *spinal* paralysis respectively; in the first we observe a very marked *tonus*, (contraction;) in the second, abolition of *tonus*, (flaccidity;) in the first, we have *augmented*, in the second, *diminished*, irritability of the ultimate nerves and muscular fibre. In the first, too, there was agitation of the arm on any emotion; in the second, none. I had no satisfactory mode of testing the existence or absence of *reflex* action.

"The physiologist, and *now*, I think, the practitioner, also, will see the value of these phenomena to medical *science*, and bring their translation into diagnosis.

"In *hemiplegia*, the seat of emotion, the source of tonus, and the source of irritability, are left; in *spinal* paralysis, the seat of emotion, the source of the tone of the muscles, and of the irritability of the muscular fibre, are removed. It must be remembered that *in both cases* the muscular mass was *equally atrophied*. What are the obvious physiological inferences from these facts, and what are their practical advantages in a diagnostic point of view? I leave the replies to these questions to my readers, observing, that the first must be diametrically opposed to the opinions recently advocated by the late Dr. J. Reid, by Dr. Carpenter, Dr. Todd, &c. The cases themselves, with many others, have all been witnessed by others so frequently, and so carefully, that they may, I believe, be received as accurately ascertained facts, from which equally cautious inferences may be fearlessly drawn. Are not these inferences — first, that the cerebrum is the seat of *volition;* second, that a lower portion of the encephalon [the medulla oblongata] is the seat of *emotion;* third, that the medulla spinalis [spinal cord] is the seat or source of tone or tonicity in the muscular system; and fourth, of the irritability of the muscular fibre; and fifth, that the two last are not dependent on nutrition *merely?*

"I may here add that the cause of *cerebral* paralysis is, chiefly,

the injured substances of the *cerebrum;* whilst spinal paralysis may arise from the injured substances of the *spinal marrow*, or from the injured substance or function of *spinal nerves:* any disease, in effect, which *severs* the influence of the spinal marrow from the muscles. In this sense, for example, the paralysis arising from *lead* is spinal paralysis.

"It is well known that in this disease the tone of the muscles and the irritability of the muscular fibre are diminished. I may here observe, that the hand and arm, contracted *by tone from cerebral paralysis*, are contracted symmetrically and without distortion, — all the muscles being equally affected, — the flexors overcome the extensors, the arm is bent, and the hand closes firmly but regularly. In spasmo-paralysis, on the contrary, *certain* muscles only are excited to contraction; and that contraction is irregular, clonic, and tonic, and the arm and hand are affected with various deformities, scarcely admitting of description, but which it would be highly interesting to depict."

Dr. Hall, therefore, laid down the following propositions: —

"If the hands of a healthy person be subjected to the action of electro-magnetic currents, they are energetically *closed;* the flexor muscles being more massive and powerful than the extensors, the former are more forcibly contracted than the latter; it is their *power*, not their *irritability*, which is tested."

But it is to an actual case in point that we must appeal; and I beg here to introduce an experiment, made to determine the question before us, viz., that of results obtained by the two kinds of electric current apparatus to which I have adverted. I give it in the words of Mr. Smith. This experiment was made on the 10th of November, 1847.

"In a case of hemiplegia of three years and a quarter's duration, in a man aged twenty-eight, the arm being slightly wasted and the hand contracted, the leg only a little enfeebled, we first applied the continuous primary current from the common Cruikshank battery; the two hands being placed in salt water in one basin, while the feet were in another; then, on using a small *number* of plates, the muscles of the paralyzed arm were found to be slightly affected by the current, but which did not in-

fluence the unaffected arm when applied to them; then, on augmenting the number of plates, both arms were moved, but the paralytic arm more than the other. We now substituted Hearder's electro-magnetic apparatus in the place of Cruikshank's battery. Both arms were now moved, but the unaffected more than the paralytic arm, the muscles being more powerfully contracted, as observed both by the sight and touch — a difference which became still more obvious as the power of the apparatus was augmented.

"Having thus pointed out the source of the discrepancy between the results obtained by Dr. Todd and myself, I need not proceed any further. Still, there are so many and such important questions in this inquiry, that I am anxious to be allowed to adduce fresh evidences of the statements made in my former papers. Most of all, I would call the attention of the society to the great physiological *principles* involved in this inquiry, viz., that, while volition is an exhauster of the irritability of the muscular fibre, this irritability is essentially dependent on the influence of the spinal marrow. I wish to call their attention, also, to the important application of galvanism *as a test* of that irritability, and as a diagnostic between the cases of paralysis, in which, first, the influence of the cerebrum, or, secondly, the influence of the spinal marrow, is severally concerned; for both these doctrines remain in their full force.

"*The Terms employed.* — Before I proceed, I must also take this opportunity of defining the medical terms employed by me in this discussion. In the first place, by *cerebral* paralysis, I mean any disease which *severs* the influence of the spinal marrow from those limbs that are paralyzed. In my former memoir, I referred expressly to the cases of paralysis arising from the severed influence of the spinal marrow, as distinguished from those arising from the severed influence of the cerebrum, merely.

"Cerebral paralysis usually depends upon disease of the cerebrum; but spinal paralysis may depend on disease situated in any locality, even in the cerebrum, if *so as to sever* the influence of the spinal marrow from the paralyzed muscles. By the term paralysis, too, I mean *pure* paralysis; and I carefully distinguish

such paralysis from cases in which *spasm*, excited immediately from some disease affecting the spinal marrow, (or system,) is superadded — cases which I have recently distinguished by the term *spasmo-paralysis*.

"It is especially necessary to distinguish between such cases as, from involving "some disease affecting the spinal marrow itself," are attended by *early* spasmodic affection, and those cases of pure cerebral paralysis, in which spasm supervenes at a remote period, from the physiological action of the spinal marrow on muscles from which the influence of volition being withdrawn, the irritability of their fibre is augmented and their permanent contraction induced, presenting the only case, probably, in which such contraction is physiological, or pathological, only in a secondary point of view.

"It is true that Dr. Todd has referred the *early* and the *tardy* contractions in hemiplegia, or cerebral paralysis, to the operation of other causes, but it is equally certain that Dr. Todd's views are erroneous; for both experiment and observation prove that no condition of the cerebrum, when *limited* in its influence to the cerebrum, can induce spasmodic action.

"An equal, or rather a double error is committed by Dr. Todd in reference to the action of strychnine. It has been amply proved that strychnine acts on the spinal marrow, and only on the spinal marrow. Throughout this inquiry it is essential, not only *that our instruments should be identical*, but that our terms should bear a meaning at once specific and accurate. The questions submitted to fresh experiment are, —

"1. Are there cases of paralysis in which the irritability of the muscular fibre is greater in the paralytic than in the unaffected part of the limb?

"2. Are there cases of paralysis in which the reverse of this obtains?

"3. What are these cases severally and respectively? Are the former cases in which the influence of the cerebrum *alone* is severed? and are the latter cases in which the influence of the spinal marrow *also* is intercepted?

"4. Is the galvanic battery, or trough of Cruikshank, cau-

tiously employed, a fair *test* of the irritability of the muscular fibre in paralytic limbs? and consequently, diagnostic of these two kinds of paralyses?

"In the prosecution of these questions many precautions are required. In the first place, it will always be observed that the patient is timid on the first application of the galvanic current. The effect of surprise and sudden sensation, in wincing, starting, &c., must be carefully distinguished from that of the galvanic influence on the nerves and muscular fibre.

"2. The degree of the galvanic force should never be — because it never need be — such as to give *pain*, far less such as to jerk the limb out of the basin. Such violence must complicate the phenomenon, and confuse the results. The galvanic current force should be the *mildest* which can produce an obvious effect.

"3. The first effect of a paralytic seizure is one of shock; probably of diminished irritability of the muscular fibre. *Time* must be allowed for the restoration, as well as for the augmentation of this property. It is, therefore, only after a certain lapse of time, that it is proper, or perhaps safe, to apply galvanism, especially if the patient be timid.

"4. Within a very few days of the paralytic seizure, there is, frequently, a rapid and considerable recovery of voluntary motion; afterwards the recovery is much slower, and much less marked. The former is the recovery from *shock;* the latter, diminution of the actual disease.

"5. Lastly, in some cases there is NO recovery. In these cases I think it probable that there may be no augmentation — perhaps no restoration — of the irritability of the muscular fibre. In one such case, after the lapse of seven weeks, the muscles of the paralytic arm remained less susceptible to the proper galvanic influence than the unaffected limb. Dr. Hall then relates several cases in which the galvanic current was used in diagnosis, by testing the irritability of paralyzed muscles. In the first case, what had been supposed to be paralysis of the facial nerve was shown to be cerebral paralysis, for the muscles of the paralyzed side were more affected by the galvanic current than those of the sound side. In a case of a real and simple facial paralysis, the muscles of the *un*paralyzed, healthy side, were most affected.

"In another very interesting case of paralysis of one leg, the affection had been supposed to be partial paraplegia, and therefore spinal; but on applying the *test* of a galvanic current from Cruikshank's battery, the muscles of the paralytic limb contracted, when no motion observable could be produced by it in those of the sound limb. The paralysis, he thought, was thus shown to be cerebral; and by close investigation of the case, it was found that the patient had felt tingling of the hand on the same side of the paralyzed leg. It is here worthy of remark, that on using Hearder's electro-magnetic apparatus, upon the same case, *the effects were reversed!* The unaffected limb was now jerked violently, when, with the same current, the paralytic limb was scarcely moved (?)"

Dr. Hall therefore adopted the following rules as *law* in his view: —

"1. That cerebral paralysis *may* exist alone.

"2. That spinal paralysis of course *implies* cerebral paralysis.

"3. That ganglionic paralysis *may exist with or without* muscular spinal paralysis. In case of a transverse division, or disease of the tri-facial nerve, we have ganglionic paralysis; and in a case where the digital nerve was injured, I found the nail ceased to *grow* as formerly. But as spinal paralysis implies cerebral paralysis, it also implies ganglionic paralysis. I have," he says, "at this moment a patient, who, from inflammation of the sciatic nerve from a cold, has lost the power of the limb, and the muscles are absolutely unaffectable by any galvanism — are atrophied, heterotrophied, and, I suppose, are changed into fat. Now, by restoring the healthy condition of the *nerve*, will the morbid change of structure undergo restoration? This is a question. It will require research and experience; but I propose shortly to add to this present brief sketch some more ample details." But he did not live to accomplish it.

Dr. Marshall Hall was thus probably the first to direct the attention of the medical world to the employment of electric currents *as a peculiar means of diagnosis* for and between certain paralytic diseases. But as he assumed, "that the brain is

the exhauster of muscular irritability by the acts of its own volitions," he could not deduce or arrive at any rule, because such a position was not tenable. Much has been written since that day upon this subject, by other able men who joined issue, as Copeland, Todd, Perera, Duchenne, and many others.

The most recent, correct, and concise views we find on this question are deduced from the very excellent work on Nervous Diseases by Dr. Todd, of King's College, London. He concludes, that Faradaic currents do serve as a test in the different cases of hemiplegia, to distinguish between an *irritating* and a *depressing* lesion of the brain, but not as a means for distinguishing between cerebral and spinal paralysis. He observed, that *in certain cases*, the paralyzed muscles responded by contractions to the electric excitant very readily, even more so than the sound side, and that in these cases the muscles of the palsied limb always showed more or less degree of rigidity. The degree of this response to the electric stimulus, he concludes to be within certain limits, in proportion to the degree of rigidity; and this latter is in proportion to the extent of the irritating clots, or cysts, *that still exist* within the brain. But in another class of these cases, this stimulus produced very little or no contraction at all; and these were noticed to be those cases usually where the muscles are already more or less wasted. Then in some other of these cases, he found that although the paralysis was almost complete, yet the currents produced equal response in the healthy limbs and palsied limbs of the same patient. These he observed to be cases of true cerebral apoplexy, but occurring in previously healthy individuals who were generally in the prime of life.

He holds, therefore, that *the state of the muscles* has comparatively little to do in the production of these varied phenomena, but that the peculiar effects of the applied artificial currents of induction or galvanism are rather due to the *state of nervous force existing in the paralyzed limbs;* so that, where there is little or no response by contraction, the nervous force in the nerves of that limb is *depressed*, or is so far exhausted. If in other cases the electric stimulus excites contractions of a still more lively

character in the palsied muscles, then in the healthy muscles of the sound side, then he concludes that there the nervous force is *exalted.* Then in other some, where there is no perceptible difference from Faradaizing the sound and palsied limbs, the nervous force existing here *is normal;* and all three of these conditions have their significance and interpretation.

Hemiplegia.

Hemiplegia is the term generally used to denote paralysis of one side, extending to both the upper and lower extremities; and *usually* the lesion in the brain, when this is the cause, is on the opposite side to the seat of the manifested palsy. When the lower extremity of one side and the upper extremity of the opposite side are affected at the same time, then the case is said to be a *crossed* palsy. These cases, however, are rare.

We may be prepared to find true hemiplegia far more frequently on the left than on the right side; and it is limited exactly to the median line. The attacks are various — sometimes gradually beginning in the fingers or toes, the legs or arms, and then extending successively over that side. When there is spastic rigidity of some of the flexor muscles, or cramps, or convulsions, they are to be viewed as grave attendants of this sad affection; and usually in such a case there is to be suspected some inflammatory softening of a portion of the brain, which is to be considered still more probable *if there is much pain in the paralyzed limbs, or contracted muscles.* In this state of things, postponement of the electric treatment is certainly prudent; but if already of long standing, and nothing is to be gained probably by delay, nor yet from other medication, then let the trials be made, if at all, with the greatest caution and gentleness, as regards strength of current, as well as length of *seance*, and adroit manipulations, — closely watching the effects.

Dr. Todd says, we shall very seldom find a hemiplegia produced by disease of the upper part of the spinal cord; but when this is the case, the paralysis is usually local, affecting, perhaps, the right shoulder and arm *at first*, but then soon becoming

more general. The author has recently had under treatment two cases that thus *originated*, and had resulted in a sub-luxation of the shoulder joint from the paralysis of the posterior portion of the *deltoid* and other shoulder muscles, while the *biceps* and *coraco-brachialis*, remaining intact, drew the head of the bone from the glenoid cavity. (See *Sub-Luxations*.)

We must also be prepared to see hopeless cases of hemiplegia, as the *congenital*, and not arising from recent lesion, but rather depending upon defective development and growth in some portions of the cord or brain, causing various complications of hemiplegia, as choreic, or idiotic, or stunted growth of limb or body, or sometimes all of these together with contractions of some of the flexors, and showing agitans. No sane man would think of benefiting such by subjecting them to any active treatment with electricity.

The following condensed propositions are laid down by Dr. Gull, of Guy's Hospital, viz.: If there be disorganization of the hemisphere, whether affecting the anterior or posterior lobe of the brain, implicating the *optic thalamus*, or *corpus striatum*, singly or equally; and if the lesion be of such an extent as to produce a hemiplegia, "then there will be a greater affection of the upper than of the lower extremity, and a greater loss of motion than of sensation." If the lesion has been sudden, and both the upper and lower extremities are completely paralyzed, the leg will begin to improve before the arm, and the muscles nearest the trunk will regain their power first; that is, for example, the deltoid and flexor of the elbow, will recover before the muscles which move the fingers. As regards sensation, it is sometimes abolished, (as the intelligence is also impaired or lost for a few days following the attack, if the lesion has been *sudden*,) but is soon recovered from, like the recovery of muscular power, *first in parts nearest the trunk;* but this, *first in the leg*.

According to Dr. Burdach, out of some thirty-eight cases of cerebral lesion of one side, the muscles of the face were paralyzed in twenty-eight *on the opposite side* from the lesion, while ten were on the same side. The seventh nerve, then, when involved in paralysis, *is more commonly crossed*, like that of the

body; yet the exceptions are frequent, and are to be borne in mind. He also affirms that a lesion of the third nerve, producing paralysis of the eyelid, was, in six cases, on the same side with the lesion of the brain, in five on the opposite; paralysis in the muscles of the eyeball in eight cases on the same side, in four on the opposite; and paralysis of the iris in five cases on the same side, and in five on the opposite.

In the British and Foreign Medico-Chirurgical Review of January, 1850, Dr. Gull further states the facts which have fallen under his own observation, as regards paralysis of the third nerve, as follows: 1. Pupil largest on the same side of the disease in the brain; vision being lost. 2. Eyes turned *from* the paralyzed side. 3. *Ptosis* on the side opposite to the paralysis of the extremities and the face. 4. Though no obvious affection of the *iris* or *recti* may exist, yet a patient may turn his eyes most readily *from* the affected side, and open the eye the widest on the side of the paralysis. Hence he concludes, that when the third nerve is implicated in ordinary hemiplegia, and is affected either slightly or considerably, *it is the nerve of the same side with the lesion that suffers;* whilst the paralysis of the facial nerve, and still more uniformly the paralysis of the spinal nerves, is *crossed.* These latter propositions, so far as they relate to the portio dura, we should say, however, are still doubted, by many learned pathologists.

When examining cases of supposed *cerebral paralysis*, we usually find that in a portion of the cases, the electro-muscular contractility of the palsied muscles is more or less diminished; that the muscles of such are soft and flaccid; that the polarity of the nerves is diminished. Whereas, in another portion of these patients, we find the electro-muscular response is unnaturally exalted; and these are the very cases, according to Dr. Todd, that present "*rigidities*," and probably have an *existing* irritative lesion of the brain. Then there is a third portion, although fewer in number, where there is no difference in this respect to be observed between the healthy limb and the paralytic limb. The following *rule* is thus deduced by the aid of electro-muscular contractility, and all cases of paralyzed mus-

cles may be arranged in one of the three following orders of conditions:

First. Where the electro-muscular excitability of the affected muscles, both in regard to their muscular sensibility and contractibility, *is lost, or very nearly so.*

Second. Where the response to electrization is moderately prompt, i. e., much *as the standard in health.*

Third. Where the response of electric contraction is found evidently *increased, even above the healthy standard.*

Now, if we examine these cases, we find in the first class, or those where the electro-contractibility and sensibility are nearly if not *quite lost*, we have, in all probability, a case of *lead palsy*, or of *traumatic paralysis*. But we should bear in mind, however, that some hysterical and rheumatic paralyses, if of *long standing*, do present the very same peculiarities, and that the same may be presented occasionally in diseases of the cerebro-spiral axis; so that other evidence on these points must also aid to the ultimate diagnosis.

Then, if we examine the second class, or those which show a *natural* response to the effects of the current, i. e., both by muscular sensation and contraction, the same as would be produced if the current were applied to the same set of muscles on the sound side, and, *if of long standing*, then we have, in all probability, a case of curable *cerebral paralysis;* but if the case has a history of but recent date, and other evidence also tallies, then it is more likely to be a *hysterical* or *rheumatic* palsy, or a spontaneous paralysis, that has arisen from local cold, or fatigue; but that there is *no lead cause*, nor is the continuity or integrity of the nervous communication from the affected muscles to the spinal cord interrupted, we may rest fully assured.

Then, again, if we examine the class of cases where the response *is exalted above the natural*, when the Faradaic currents are only applied as usual to the palsied muscles, then, in all probability, we have a case of actual brain disease, the result, perhaps, of a long previous apoplexy, the coagulated cyst of which remains as a *persistent irritating lesion*, which is situated within the cranium, and thus sustains the peculiar and true

brain paralysis. These cases are not reckoned as suitable or safe for the *electro*-medical treatments.

Early and Late Rigidity, or Tonic Muscular Contractions from Brain Lesions. — Here Dr. Todd makes a marked distinction between the "*early rigidity*" that attends some cerebral paralyses, which occurs soon after the attack, and those cases of "*late rigidity*" which are connected also with cerebral paralysis, but occur only after a certain time. In the former, or early rigid contraction, it is shown most usually in the *biceps* muscle of the arm, and in the hamstring muscles of the thigh, but usually greater in the upper limb than in the lower. This varies in amount, in different cases, from a mere increase in plumpness up to a strong contraction that is almost tetanic. The circulation is found, however, as vigorous as in health, and the heat is at about par; but the paralyzed muscles are generally *more responsive* to the electric stimulus than those muscles of the healthy opposite side. It is quite obvious, says Dr. Althaus, in his excellent treatise on medical electricity, that in a case of this kind there is not the slightest reason for attempting the therapeutical application of electricity, which would, in all probability, aggravate the symptoms, arising, as they do, from an irritative lesion of the brain. I will quote him further, nearly in his own words.

"As in one class of cases of cerebral paralysis, the muscles can take on *early* rigidity, so also in another class of such affections, the muscles may be exempt from this, but ultimately present the state of *late* rigidity. Muscles of such cases, having been flaccid and wasted for a certain length of time, — that is, since the first attack, — then gradually acquire more tension, and become shortened. The *tendency* to assume this rigid state of muscle, under these circumstances, is more marked in the arm than in the leg, and more in the flexors than in the extensors. It is generally supposed to be caused by the gradual shrinking of the cyst, which acts as an irritating foreign body in the brain. In most of these cases the electric treatment should be cautiously resorted to, or not at all. But in some cases of long standing, an electric excitation of those muscles which are

the antagonists of the contracted and rigid muscles may serve to restore the disturbed equilibrium between the groups of muscles. The following case, he says, may serve to illustrate this : —

"Case of *late rigidity:* late muscle contraction — the sequel of a healing brain lesion. A man, named Marsh, had four years ago an apoplectic attack, with consequent paralysis of the right side. The paralyzed muscles afterwards assumed a state of rigidity which has not undergone any considerable change since that time. At present the patient can with some difficulty walk ; but the right arm is perfectly useless, as there exists a rigidity of a number of muscles, viz., of the *coraco-brachialis*, whereby the arm is adducted to the side ; of the *biceps*, so that the forearm is bent upon the arm. If forcible extension of the forearm is attempted, the *biceps* offers a certain resistance to it, but no pain is experienced during the forcible extension.

"Stiffness is also marked in the *triceps*, although much less than in the *biceps*. It became evident, if complete flexion of the forearm upon the arm is attempted, so as to place the fingers on the *acromion* of the same side, then the extensor muscles of the wrist and of the fingers would be in a state of complete rigidity. If the hand is strongly extended upon the forearm, then the fingers are as firmly pressed against the palm of the hand, so that the patient is obliged to cut his nails very short in order to prevent injury to the skin from them. The tendons project like tight strings beneath the skin. The patient affirms, however, that he experiences no pain when a forcible extension of the wrists and of the fingers is attempted. There is not much wasting in the muscles, and the excitability to the electro-magnetic stimulus is very trifling in the extensor muscles of the forearm, while the flexors of that forearm contract very readily under the influence of a gentle current. The stiffness of the muscles of the lower extremity is much less considerable than those of the arm ; it is, however, distinct in the hamstring muscles, and in the flexors of the toes. In walking, the patient drags the paralyzed leg and foot.

"I supposed that in this case the cyst in the brain might have

shrunk to a very small volume, and that the *un*balance in the equilibrium between the different sets of muscles of the upper extremity might no longer be exclusively due to the lesion in the brain, which undoubtedly was the primitive cause of it, but also due in some measure to the long-maintained overweight of the contracted flexors over the paralyzed extensors. I thought that by administering the electric stimulus to the relaxed *extensors*, the equilibrium might be restored. This view was confirmed by the result of the treatments; for after I had Faradaized the extensor muscles of the forearm for some time, the tendons of the flexors, (by reflex action ?) which had before projected like tight strings beneath the skin, now became soft and flexible. The patient was able of himself to open his hand and stretch his fingers. But having been some time afterwards exposed to violent cold, and a draught of wind, the flexors again assumed a degree of rigidity. By further treatment, he again improved ; but he left the hospital before being completely cured."

We can quote a multitude of facts in support of the accuracy of these propositions, the importance of which is fairly shown in such cases as where the exact cause of the paralysis is not so apparent or decided, as for instance, in traumatic cases, where there is a tumor compressing the nerve trunk, (or other deep-seated cause that produces the paralysis, or pain, or both) — a phenomenon the nature of which is not hid from this test, in the majority of contusions, compressions, or disorganizations. Dr. Duchenne gives a very marked case to illustrate the accuracy and value of this diagnostic power in a patient, where he, from his great experience and confidence in the electric test, was led to attribute the paralysis of the case *to some alteration in the nerve trunk* that led to the affected muscles, notwithstanding the contrary appearances. From a careful examination of the case, by this electric questioning of the nerve and muscle witnesses, there was clearly proved a lesion existing at the level of the emergence of those nerves which constitute the cervical and brachial plexus of the right side. This local lesion, so masked, he found was due to an exostosis of long standing, and which he

succeeded in curing by means of electric currents, and with it the attending paralysis.

From the foregoing facts and deductions, we may be led to suppose that wherever there is a loss of electro-muscular contractility in given muscles, we may fear that those muscles are lost forever; but we must also recollect that the retained electric *sensibility* in a case where there is lost electro-contractibility, which a patient may still now and then exhibit, while the most implicated muscles are subjected to strong induction currents, is, as we have before said, *certain evidence* that the nervous communication with the central organs is not utterly cut off. If, then, the muscles have not degenerated by change of structure into fat, we are after all allowed to hope, but not flatter — to work, but not promise; for now and then we do realize, after patient and persevering treatments of such, the happiest results.

We think we are justified in summing up the following as the order of succession, and amount of *therapeutic phenomena*, such as are manifested in these and similar cases, when under the influence of Galvanic or Faradaic treatments:—

First, there is an exaltation of sensibility which may amount to considerable, but transitory hyperæsthesia in the sensitive branches of those nerves touched by the current while reaching the underlying muscle, or muscle groups.

Second, there is a more or less speedy return of voluntary movements in the muscles that were paralyzed, but in only such as did not entirely lose their susceptibility to the electric stimulus; and next, those that did not entirely lose both their electro-contractibility and muscular sensibility.

Third, there is an increased size, solidity, and nutrition of the blighted muscles; and then there is soon shown returning voluntary movements, first in the muscles, and then in the limbs — and that, first nearest the body, and then successively farther out, and last of all the hand or foot. But this latter succession we have not unfrequently seen reversed in the order of events.

Professor Trousseau of Hotel Dieu, in speaking of a case which was a most complete hemiplegia, as regards *movement*, while the general sensibility, the senses, and the intellect were manifestly

preserved *un*impaired, says, "I find myself inclined towards the common opinion of hemorrhage, and yet I feel at times that there are powerful reasons for suspending this judgment — reasons that I derived from the nature of the paralytic accidents themselves. Besides, I remember to have heard M. Recamier teach — and I have since observed it to be so myself — 'that, when there is *dissonance* among the symptoms in this class of grave cases, they are due to *ramollissement;* while, on the other hand, we must conclude that hemorrhage exists where there is a *consonance* in the paralytic phenomena.'" There is force in the distinction laid down by Recamier, and it remains demonstrated, at any rate, that a *sudden* paralysis of a portion of the body *may* be the result of a *ramollissement.*

The "Electric Test" of Paralysis.

We may fairly conclude now, that all cases of cerebral paralysis presenting for treatments — say a few months after the causing attack — can be pretty clearly and reliably arranged, by aid of the electro-magnetic test, into *three classes*, two of which are not as yet suitable for this treatment, while the one and larger class of patients, i. e., *where the "electro-muscular contractility" is diminished from the healthy standard*, we may very reasonably hope for a still further restoration, by the aid of electro-therapeutics, or even a complete cure, if at once treated and skilfully managed.

Again, we may conclude that there is no kind of paralysis, where we find *exalted electro-muscular contractility*, except in those cases where the paralysis is maintained by an irritative lesion in the brain; and the greater the irritative brain lesion, the more marked is the electro-responsive phenomenon in the affected muscles, to the given moderate current.

Again, we must not conclude, on the other hand, that all lesions of the brain are necessarily irritative, unless showing for months or more, and to the present time, exalted electro-muscular excitability.

Again, if, on testing, we do find the muscles of a paralytic

limb to respond by contractions, on the application of a given *moderate* current, *more promptly and powerfully* than do those same set of muscles on the opposite and sound side, we may fairly conclude *that the paralysis is due to some existing brain disease*, and the lesion, whatever it may be, is of an *irritative character*, and that the case is not ready for this treatment. The following is a case of *hemiplegia resulting from apoplexy, and showing the electro-muscular contractility diminished.*

First Class.—Captain G., aged forty-five, has a noble frame and powerful muscles; is of a healthy family, and has led an active life. Last fall, some eight months ago, he had an apoplectic attack, which well nigh destroyed him. He finally rallied, however, after a loss of consciousness for several hours, but very gradually and doubtfully. After some time he was found completely paralyzed on his left side, including both his arm and leg, and also the right side of the tongue and face. He is a gentleman in good circumstances, and had every thing done for him in medical attendance and care, that could be, during the fall and winter. When he was brought to my electrical rooms, this past summer, he showed a recovery of nearly one half of the original paralysis; but the mobility in the tongue, face and leg, is greater than in the arm. This latter was quite helpless; yet he appeared to complain most because he could not walk. He was able to help himself considerably, but in a moderate and trembling way. By the aid of an attendant each side of him, he can get out of the carriage and work his way into the rooms, which are on the ground floor. I cannot learn that he indulges in any excess, and besides, has dismissed the care of all business since the accident. His pulse is sixty-six; his respiration twenty-six. He finds much difficulty in the managing of his hands at the table, and still more in adjusting and buttoning his clothes. His mental faculties are correct, but his wife says he has not his usual quickness of thought or speech; has no pain in his head or limbs, and his speech is becoming improved. The whole left side of the body and limbs is soft, flaccid, and cold, and a little diminished also in size and sensibility, with spots of purple, and numbness, but no appearance of rigidity of any of the paralyzed

muscles, as I was able to make passive bending and extension of all the joints. The extensor muscles have suffered the most, as the voluntary aptness and power of extending are less than bending.

I judged such a case suitable for testing by Faradaic currents, in order to decide on a future course. Accordingly he was placed in the adjustable operating chair for a *test seance*. One electrode was placed upon the nerve *medianus* at the inner border of the biceps on the lower third of the humerus of the affected limb, while the other electrode was swept along, lower down on the muscles of the forearm, first on the extensors and then on the flexors, using but a gentle down-running current, i. e., the negative over the nerve, and the positive upon the muscles; and thus the contact was made and the soft iron magnet was cautiously and but partially introduced into the helix, that the patient might at most but slightly get the stimulus. The current was thus gradually increased; but this in no way affected the contraction of the muscles, and was but slightly felt. The electrodes were then removed from this to the right (sound side) with the current as just employed, when the action upon the muscles was amply manifest to all present.

Here, *the ascertained diminution of electro-muscular contractility of the affected muscles*, taken in connection with the *ensemble* of the patient's history and present state, re-assured me that I was right in judging his a suitable case for electrical treatment. Thus we can bring to our aid the almost exact evidence that there is, or is not any longer, an intra-cranial irritation, and hence that the paralysis no longer *depends* upon the brain lesion, or any brain cause, but is simply in the nerves and muscles, partly from the long inaction, and partly from the loss of intercommunication between these muscles and the seat of volition at the base of the brain.

This case was received in June, for Faradaic and Galvanic treatments, which were followed up every day for a month, and then less often, with only galvanic currents for some two months more, when he felt himself quite restored. He remains to-day perfectly well, but is under careful habits and moderate regimen.

Just here I will add, that from my note book I gather some practical points. He took six sittings each week of fifteen minutes each. Faradaic currents, suddenly alternated, but of moderate strength, were exclusively employed the first two weeks. One electrode used here was the half-inch disk, while the other was a two-inch sponge. The former was always planted upon some large nerve trunk, while the other traced the edges and surface of the depending affected muscles, but one minute at a time, then a rest of a part of a minute, and then *suddenly changed* in direction for another minute, and so on. One *seance* would be given to the arm, shoulder, and hand; the next, to the loins, leg, and foot. In the beginning of each *seance* there was particular gentleness and care, until the patient became accustomed to it, when the current was gradually increased to a three fourths strength of a good helix machine that was run by two Smee's batteries. After the first fortnight, the last half of each sitting was devoted to the employment of the primary galvanic current, or rather the induction currents were first used for two or three minutes, and then some half dozen minutes were occupied with the galvanic current, interrupted or *reversed* every ten seconds, either on the nerve trunks or over the spine, using from twenty to thirty Daniell's elements. The *seance* is then finished out by using stronger induction currents for extensive surface action, by *labile* movements, and through this means to awaken and produce a general but gentle reflex action. At the end of the first ten days, his friends claimed for him a general improvement. In the course of ten days more, as I find it recorded in my note book, he claims a sensible improvement for himself, as not only more strength, but as to increased warmth and plumpness of the sick limbs, with which his friends seemed both astonished and delighted. Aften ten days more, his *seance* was arranged so as to occur three times in each week, for the month to come, at the end of which the muscles were evidently much improved by the treatments, — responding more promptly to the electric stimulus, both by sensation and contraction, and there was much more voluntary control and power. The skin was not so dry and cadaverous, while the muscles were larger, more solid,

and warm. From this time he took less frequent sittings *to confirm the restoration*, while he was also initiating himself again into his accustomed business.

Second Class.—Case of hemiplegia, showing "*exalted*" *electro-muscular excitability of the paralyzed muscles, and thus diagnosticating* "*irritative disease of the brain.*" An English woman, some twenty years of age, first seen by me in the east wing of the Massachusetts General Hospital, at that time under the care of my excellent friend, Dr. H. I. Bowditch. She had the summer before suffered repeated attacks of "fits," which was followed by a hemiplegia of the left side. Since that time she has been subject to epileptic fits, which, however, have become very seldom since her entrance into the hospital. Besides, under the judicious treatment and good care she received while here, her general health improved, and the paralysis of the right lower limb was mostly recovered from, but that of the arm remained complete. There was also rigid contraction of the left fore finger and thumb, and the whole hand remained flexed upon the wrist. She suffered much from pain in that shoulder and arm, and was sleepless and irritable, yet manifested the greatest disinclination to move about the room; and still much less was she inclined to walk out, as she was somewhat able to do. It was requested that the case should be tested by electricity: accordingly the ordinary electro-magnetic machine was provided, and a medium current was applied to the *median* nerve and the depending muscles of the paralyzed arm. The results, at first, were doubtful, and for this reason the case is introduced here. Her general aspect was certainly promising, and, strange to say, I could not learn that there ever had been any *ptosis* of the upper eyelid, nor paralysis of the face; yet I felt doubtful as to the character or state of this case, as did also the physicians of the hospital. In this state of things, although she had slight epileptic attacks from time to time, it was thought advisable to repeat the electric test or treatment every few days, in a cautious way, until there should be improvement, or manifested contra-indications for its employment. In the course of a few days it was discovered

that on placing one (the positive) electrode over the nerve *medianus* of the palsied arm, at the lower third of the humerus, while the other electrode was applied, say first over the body of the flexor muscles of the forearm, and then moved transversely, but slowly, around the arm to the outer side until this electrode rested over the body of the *extensor communis digitorum* muscle, while a gentle, say one-third current, was circulating in a downward direction, it was seen that the muscles contracted entirely *too promptly and powerfully for such a current.* Particularly was this phenomenon noticed in the extensors, which now drew out the long-contracted fingers and retained them so, as long as the current thus circulated; but they fell back into their accustomed helpless rigidity as soon as the electrodes were removed. When the electrodes with the same current were transferred to the same muscles of the sound (right) arm of the patient, merely for a comparison, she said the *sensation* was greater; but we saw that the contraction was decidedly less than it produced in the palsied arm. Notwithstanding, the patient declared herself better, and, indeed, she certainly appeared better during these few doubtful treatments; but, as she was already dismissed from the hospital before we commenced the test, she soon left, and was lost sight of. It is highly probable that this fine-looking young woman was actually suffering from a tumor at the base of the brain, and could never be entirely well.

Third Class. — Case of hemiplegia, showing nearly *normal electro-muscular excitability of all the muscles.* Georgiana W., aged forty-five, of a somewhat rheumatic constitution, but otherwise always robust and well, until some years ago she had an apoplectic fit, in which she lay somnolent for some hours. She then gradually recovered, but with a total loss of speech, palsy of the left side of the face, and a complete paralysis of the right arm and leg. And thus she remained for some four months, during which time she was despaired of. But to the surprise of friends she soon after that began to recover, and that without any change of medical treatment; indeed, without any active treatment at all. Her improvement was so rapid

that in three or four months more she was, to a degree, on her feet again; her speech had partially returned, and the paralysis of the face was apparently quite restored. From this, however, until she was presented at my rooms for electric treatments, (which was several months,) there had been no mentionable change for the better, but in some respects, a losing.

Her speech I found to be remarkably slow, and quite imperfect. When she attempted to speak, the tongue was inclined to one side, and the deep fibres of the *orbicularis-oris*, were constricted. Her gait was unsteady, the arm mostly helpless, and her head felt to her, she said, as if swimming and very heavy. The appearance of those muscles that remained still affected were, evidently, in a remarkably good condition. True, they were rather delicate to the touch, but they were plump and warm.

Here I at once concluded, that we had another unsuitable case for electric treatments. It was requested, however, that the case should be tested. Therefore the patient was seated in the operating chair, and the electrodes applied in the usual manner, the one to the nerve *medianus*, and the other to the flexor muscles of the paralyzed forearm; for nearly all these flexors were totally helpless. Instantly the contact was made with the electro-magnetic machine, using a down-running current of only one third strength, and the fingers were successively contracted as the lower electrode was swept transversely across the lower portion of the bellies of the adductor muscles. But they remained as helpless as ever so soon as the current was discontinued. The same prompt response of the still delinquent muscles of the affected leg was shown to the same moderate current. The test was then removed to the sound side, and there gave very similar results. Of course, this completely confirmed my suspicions, which led me to *pro*scribe utterly all electric treatments as being too hazardous for a patient while in such a state.

In the "early treatment" of hemiplegia *from softening of the brain*, Dr. J. Hughs Bennett, of Edinburgh, believes that the most important result for the practitioner to aim at, in these cases, is *to keep down the undue frequency and force of the*

heart's action. To this end, he advises the strict maintenance of the reclining posture; and when the patient is awake and conscious, the mind should be tranquillized by every possible means. He says, again, "You will often be early consulted as to 'some expedient for promoting the restoration of the paralyzed limbs to their natural condition.' To this question, after having given a fair trial to the various means which have been proposed, (in the earlier stages,) I must reply, that I know of nothing which more decidedly benefits the paralyzed limbs than a regulated system of *exercise* — active, when the patient is capable of it; *passive*, if otherwise. As to the use of electricity, which is now much in vogue, or the treatment by strychnia, which has been recommended, I feel satisfied, as the result of a long experience, that the former requires to be used with much caution, and that the latter is very apt to do mischief, and never does good. I have seen cases in which, after the early employment of electricity for some time, that agent has apparently brought on pain in the head, and has excited something like an inflammatory process in the brain. And so strychnine also will induce an analogous condition of brain, and will *increase* the rigidity of the paralyzed muscles." (See pp. 477–479, Notes B, C.)

Paraplegia.

Paraplegia, we know, is a loss of the power of motion in the lower limbs, either partial or complete, and usually attended with inaction of the urinary bladder and rectum, with loss of power over the sphincters, and often with impairment or entire loss of sensation. When the affection arises from an injury of the spinal cord, the accession is sudden; but if from inflammation and its sequels in the spinal marrow or its membranes, or if the bones or cartilages of the spine are diseased, then the first appearance of the paralysis is more *gradual.* In this latter, there is first some abnormal sensation, which is soon followed by numbness, and this *by diminished power of motion in the lower extremities*, so that one easily trips; cannot stand long; has a sensation of weight in the limbs, and pains down to the feet.

The usual consequences of actual inflammation of the spinal cord, or of its membranes, we know, are effusion of coagulable lymph, induration of the substance of the cord, either from the inflammation, or from impaired nutrition, or from loss of vitality. This is very often followed by palsy, atrophy, and rigidity in the legs. There may be also other results, from an inflammation affecting the vertebral or the inter-vertebral substance, as caries, exostosis, anchylosis, &c.,—any of these are often the pathological causes of the existing paraplegia; the chief characteristic of which is mainly the *loss of voluntary motion*, while involuntary motions, and spasms of the lower limb muscles, are not infrequent. If the lesion is situated high in the spine, then spasmodic contractions, more or less permanent, may now and then seize the abdominal muscles, as also those of the lower limbs. Now, these involuntary motions, pains, and spasms are manifestly caused *by the still existing irritation or inflammation in the cord*, or in its membranes; or of the roots of the nerves from extravasated blood, effused pus, from caries, displaced bone, &c. In the more severe cases from injury, the urinary affection continues, and hastens on the fatal issue; but in all others, the power of passing and retaining the water is restored in some degree, and *this improvement* is one of the chief indications of the susceptibility of the cord to the restoration of its functions. The bowels, in these cases, are not only torpid, but the evacuations are very dark, and *often of a greenish*, *tar-like* appearance, and all the more so the higher in the cord is the seat of the lesion.

Sir Benjamin Brodie says he has not met with the attending symptom of *priapism* in any case where the seat of lesion was below the sixth dorsal vertebra. Another singular phenomenon, I have often observed, is that in the most profound, manifest, and complete paraplegias, the temperature of the palsied limbs is exalted; i. e., warmer than in health. This does not long continue, nor is it always present in such cases. When it does occur, however, I take it as a discouraging feature, as there will probably result, in spite of treatment, more or less atrophy and contraction in the burning muscles. But these, being facts, must

not deter from early and gentle, but persevering efforts to save the limbs, all we can, by manual exercise; by counteracting with suitable apparatus the tendencies to mal-posture from the contractions; by exercising and thus nourishing the muscle fibres by electricity, and *if cold, by keeping the entire legs and feet all the time warm.* Every hour they are allowed to remain cold the contraction and rigidity will be the greater. When, in a paraplegic affection, we discover that *anæsthesia prevails* over the loss of power, (i. e., is greater,) we must not in that case expect to find a local or circumscribed lesion of the spinal cord, but examine for a diseased action, or state, in some peripheral portions of the nervous system, *or whether there are not indications of a brain origin.* Which of these two causes prevails, the general history of the case will aid us in deciding.

Cervical paraplegia occasionally occurs, manifesting itself in the upper extremities, the legs being more generally not in the least affected; while, if they should be involved, they are always much less so than the arms. The muscles of the shoulder and arm, and more particularly the right shoulder and arm, are first affected; and, not unfrequently, this is the whole of the affection. This disease sometimes attacks both arms at once, or begins in one, and so passes over to the other also. At first there are usually pain and soreness in the muscles involved; but after existing for a longer time, no modification of the skin sensation remains, but there then exists an obstinate paralysis, which probably commences in the muscle fibres themselves, *or through some perverted action* of the nerves of those parts; for there is *wasting* as well as *palsy*. For this employ Faradaization.

A sailor, just arrived, as second officer in the bark S., from the Mediterranean Sea, presented with paralysis of both arms, — complete in the right arm, but partial in the left, — produced by protracted *cold water affusions* for his fever, immediately after sailing from Smyrna. There were softness and atrophy of all the shoulder and arm muscles on the right, and those of the left doubtless tending to the same condition. For this otherwise nobly framed fellow I adopted localized Faradaization, or rather by my *team-electrodes*, as it were *bathed him with electricity* over

the affected limbs, shoulder muscles, and the upper portion of the spine, by employing very brisk currents through labile (moving) electrodes. This was done daily, and in a fortnight he was quite restored.

Dr. Dewees states, as the result of his experience, that in paralysis resulting from the various affections of organic nerves, or where nutrition, local or general, is deficient, he prefers the primary current of the compound battery, applied in the *inverse* direction; but in "muscular palsy" the current should be directed *with* the nervous ramification.* He recommends, therefore, the sustained primary current, wherever it is desirable to exercise an organizing power over the affected part, but a resort to induction currents when more stimulation and exercise of the nerves and muscles are desired.

Paraplegias of all grades, then, may be arranged in *three* classes, each category depending upon a lesion of a different kind, and each distinguished by symptoms of its own. We cannot do better than to give the condensed views of Dr. Gull, of Guy's Hospital, on this subject; and they are arranged much as follows: —

1. The first class of paraplegias *are those resulting from lesion of the spinal cord.* There may proceed, then, from this, a general paralysis of the parts below the injury, whether the lesion be confined to the anterior or posterior portion of the cord, or whether it extends through the entire substance of the spinal cord; and in either of these cases *there is greater loss of motion than of sensation*, the sensation, usually, being little, if at all, impaired, whilst the loss of motor power is complete; and this he considers to be almost invariably diagnostic of the spinal origin of the given case of paraplegia. He affirms that, after an attentive search, and having great facilities for this, he cannot find a case of uncomplicated pressure on the cord, or of disorganization of the cord, in which the *loss of sensation* predominated, or in which there was simply loss of sensation. He says, "My attention has now for years been much given to *post mortem* appearances; but I have not met with

* New York Journal of Medicine, May, 1847.

a case that does not confirm the foregoing, nor are there amongst the numerous cases of lesion of the spinal cord, which are in the records of this hospital, any which show that one part or column of the cord, when affected, is attended with anæsthesia, without loss of motion, though, as we have seen, the loss of motion usually occurs without anæsthesia." But we must bear in mind, that in paraplegia from disease of and about the spinal cord, the spinal nerve roots, as they leave the cord on either side, are not unfrequently implicated near their junction with the cord. Thus, Dr. Abercrombie cites the case of Count de Lordat, which was a paralytic affection of the left arm, following an injury to the neck from a fall, and the opposite arm became *numb*. By the post mortem examination this was explained; for there was found, not only *induration* of the cord, but "a compact and tendinous condition *about the roots of those spinal nerves*, owing to a thickening of their investing membranes." The former produced the paralysis of motion, the latter the numbness. There are also, now and then, cases of *cervical* paralysis, which see under that head.

2. The *second class* of paraplegias are those in which the loss of *sensation* is greater than that of motion. The cases under this category naturally arrange themselves into two groups, according to their seat of lesion; the one being *peripheral*, affecting the nerve trunks in their course; the other being *central*, and in that case it is *encephalic* instead of spinal. These form the second and third classes. The first group, where the cause is peripheral, is the *second class* as reckoned by Dr. Gull; while the second group, which is caused by brain lesion, makes the third class. The second class, then, *are known by the preponderating anæsthesia arising from peripheral causes*. As the grandest example in this (second) class of paraplegic diseases, is quoted the *epidemic of Paris*, in the spring of 1828, so graphically described by Dr. Chomel. This curious affection usually set in with an extraordinary and exquisite *exaltation* of the general sensibility, which, however, gave place, after a few hours or days, to a general *diminution* of sensibility, and this proceeded even to the extent of a complete *abolition* of sensation. The power of

44 *

motion also declined, but in a far less degree. In most of these numerous cases, recovery took place, although the palsy was very capricious — sometimes self-vanishing, and then again reappearing. In some cases, however, the disease went on to a fatal termination. This wide-spread disease had all the characteristics of a malady induced by the presence of some poisonous agent in the blood. *Prevailing numbness* is then the characteristic of this class.

3. The *third class* of paraplegic diseases, already partially defined under the second class, are to be recognized also both by their diminished vitality, and *peculiarly* diminished nerve force. These are the cases that result mainly from anxiety, deep mental depression, irregular practices, &c., which are attended with general diminution of the encephalic and other nervous forces. In these there is a greater proportional impairment of sensation than in spinal affections. Whatever impairment of the power of voluntary motion there may be, is often in a greater degree *owing to the want of the guiding influence of sensation*, (muscular sensation?) than to any direct loss of motor power. Therefore the gait of such persons will be found to be very much like that of a drunken man. Where the anæsthesia in these cases is complete, the person is obliged to employ the *visual sense* to enable him to walk at all without stumbling, as a substitute for the "muscular sense." Thus, says Dr. Gull, "one patient told me he could not walk without looking down at his feet all the time, because he felt as if his legs were cut off below the knees. Another patient said he had to do so because he had no apparent weight."

The author has seen a multitude of these cases in the last few years, who came from almost every part of the Union for electro-therapeutic treatment. Such, indeed, probably form the very largest class of all nervous affections that present for this remedy; and this to my mind is not strange, since being convinced of the almost every-where prevalence of venereal excess, (for self, or to gratify another!) or intense mental anxieties, and disappointments, that so perpetually harass and *exhaust* the human nervous system. But I was about to say,

that a large number of these cases not only "had no sensation of weight," but they have so frequently complained to me of their suffering when awake, walking, or asleep, from the *sensation of rising*, and being unable to keep their feet down on the ground or floor. This sensation, by times, harasses these patients prodigiously. As they recover, this vanishes. When this *peculiar* sensation appears in a less degree, however, then it is described by the patient as if the limb was covered with a glove or stocking, and as if the impression was outside of this. Notwithstanding the numbness, there is still the perception from pricking or pinching of the integuments; and what is particularly noticeable, this numbness often extends only to about the elbows, and as far as the knees.

Moreover, there are frequently, *in these cases*, affections of the special sense, as flashes of light, *muscæ volitantes*, dimness of vision, and noises in the ear. One other peculiarity noticed by Dr. Gull, and which I can verify, is, that the most moderate pressure on any of the nerve trunks, as simply from lying on the arm in bed, or sitting upon the edge of a chair, or the like, will very readily render the nerve so compressed, completely anæsthetic, with deep and painful prickle, which often renders the limb helpless, at least for a very short time. This symptom is evidently from delicate constitutional structure, or from exhausted or attenuated nerves. That the seat of this threatening affection is encephalic, rather than spinal or peripheral, appears scarcely questionable; and that its cause is rather a delicate nerve structure, or a disordered state of the general nerve nutrition, than any sort of local lesion, is equally certain. Let the patient but avoid the mental *over-work*, or correct all evil habits, and electro-therapeutics, with other rational medication, can cure this nervous affection.

In most cases where paraplegia arises from actual organic disease within the spinal sheath, there is, at some time or other, some degree of palsy of the intercostal muscles, or of the diaphragm. In general, the *pain* in these cases is referable to the base of the brain. But in some cases they refer the pain to the forehead, and are able to control the urine and fæces; sensation

remains normal, while the palsy is only that of motion; and this would lead us to suppose that the spinal cord only is diseased, or else is compressed with effusion within the theca, which may gravitate towards the lower portion. Now, where there is no history of palsy of the diaphragm or intercostal muscles, I blame the kidneys, and put the patient immediately upon the mutual use of electro-magnetism to the back and loins, and the internal exhibition of tinc. cantharides in thirty-drop doses, repeated two or three times a day, and alternated with large draughts of lemonade made of the *acetate of potassium*, which, if followed with an increased flow of urine, will almost surely be followed by a recovery. If strangury should ensue, (and there is no existing stricture,) give twenty or thirty drops of laudanum, in a small starch injection, or camphor by the mouth, and it will immediately disappear. When the cantharides prescription is dropped, continue the daily or semi-weekly use of electricity to the spinal muscles, loins, and abdomen. (See p. 477, B, C, and Appendix. F.)

Catalepsy.

Catalepsy, it will be remembered, is the almost only complete and general state of "palsy of *motion*" that can exist, without instant destruction of life. It rarely continues long, although it may recur from time to time. The fact is, this *is a complete loss of the power of the will*, while there still remain both consciousness and sensation, but these in a very diminished degree. The sphincters are entirely unaffected; the *respiration* is so slight that it is perceived only with the greatest difficulty, and sometimes with uncertainty; the pulsations of the heart are extremely weak and frequent, or slow and irregular, and the pulse at the wrist may be too minute to be made out. Powerful currents of electro-magnetism, quickly alternated, or the sparks, or the Leyden jar shock of static electricity, is here called for, "to break the spell," and restore the dominion of the will. By these means, we usually succeed, and that quickly, except in some protracted cases of this "*sus-*

pended animation," where perhaps it is wiser to proceed gently; as in attempting to raise a flame, we must always avoid putting out the taper.

Local Palsy.

Paralysis of a muscle, or of a group of muscles, situated on the extremity, or on the body, is of every-day occurrence. This is caused by some one or more of a thousand circumstances that produce a lesion of the sentient nerves, or motor nerves; sometimes the cause can be traced, and sometimes it cannot. Lead poison, rheumatism, kidney affection, extreme cold or heat, prolonged *monotonous* labor, hysteria, concussion, wounds, &c., may often be the cause. A severed nerve will produce a simple palsy. A wounded nerve, in some instances, not only produces a palsy, but also *pain and progressive atrophy.* For these and other considerations, we will treat of "local palsies" separately under their respective heads. Nearly the whole of this tribe of affections are amenable to well-directed electrical treatments.

Fig. 87. A View of the Muscles on the Front of the Forearm, (Flexors.)

Anæsthesia.

This is paralysis of sensation. It is precisely opposite to hyperæsthesia. In cases where the ordinary *want of feeling* is

1. Lower Portion of the Biceps Flexor Cubiti.
2. Brachialis Internus.
3. Lower Internal Portion of the Triceps.
4. Pronator Radii Teres.
5. Flexor Carpi Radialis.
6. Palmaris Longus.
7. Part of the Flexor Sublimis Digitorum.
8. Flexor Carpi Ulnaris.
9. Palmar Fascia.
10. Palmaris Brevis Muscle.
11. Abductor Pollicis Manus.
12. Portion of the Flexor Brevis Pollicis Manus. The line crosses the Adductor Pollicis.
13. Supinator Longus.
14. Extensor Ossis Metacarpi Pollicis.

simply from lost peripheral susceptibility to impressions, from nerve exhaustion, as by over-use or over-excitation, or if it is what is called functional, as, for instance, is often found in females about puberty, then electricity can act with its own peculiar potency and success. On the contrary, when the cause is from organic lesion, it is scarcely necessary to repeat, that no benefit can be expected from electricity, or any other means whatever; for anæsthesia may be caused by diseases of the nervous centres, nerve trunks, or of the sentient nerves. Whatever be the original lesion, that must be first subdued. Then, if we very sharply "Faradaize the skin" with strong electro-magnetic currents, using the wire brush or metallic balls as the electrodes, and applied close together, the sensibility will be most readily awakened and reëstablished. (See pp. 238, 341, and G, 5.)

Traumatic Paralysis.

If all the fibrils of a nerve trunk are destroyed, then the properties of the depending muscles are totally lost. Cases of this kind are entirely incurable and beyond hope, unless a regeneration of nerve and function can be brought about. Of

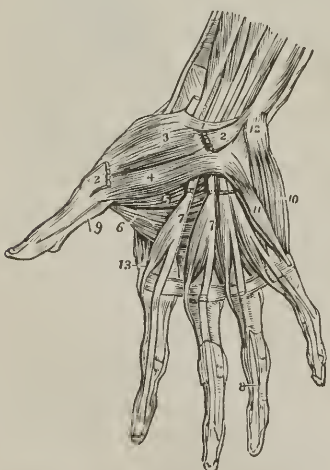

Fig. 88. A View of the Muscles of the Palm of the Hand.

1. Annular Ligament.
2, 2. Origin and Insertion of the Abductor Pollicis.
3. Opponens Pollicis.
4, 5. Two Bellies of the Flexor Brevis Pollicis.
6. Adductor Pollicis.
7, 7. *Lumbricales*, arising from Tendons of the Flexor Profundus Digitorum.
8. Shows how the Tendon of the Flexor Profundus passes through the Flexor Sublimis.
9. Tendon of the Flexor Longus Pollicis.
10. Abductor Minimi Digiti.
11. Flexor Parvus Minimi Digiti.
12. Pisiform Bone.
13. First Dorsal Interosseous Muscle.

late, this is ascertained to be accomplished in some cases by nature alone, under favorable circumstances. It is believed by Marshall Hall, Duchenne, and Remak, that this can be greatly promoted by a correct use of electricity, not only where nature is in some degree tending to restore a solution of continuity, but also in those unfavorable cases where the nerve is, as it were, profoundly stunned, or changed, and has completely lost its *capability* for action. It has been proved by ample wounds in the living dog, that the nerve is reunited, being entirely new formed through the tissues of the cicatrix.

Dr. Brown-Sequard has established by microscopic research, that in some cases where nerve trunks have received an actual solution of continuity, and the paralysis for the time was complete, yet the nerve fibres, under favorable circumstances, can become entire again, and continuous *through the cicatrix*, so as to communicate with the brain in a normal manner. Dr. Prevost, as also M. Bernard, have made special observations to this end, by destroying a portion of a nerve trunk in a living dog, and then waiting for a perfect healing, and testing for the reëstablished nervous function, then dissecting down upon the spot of previous mutilation, and they find that the nerve fibres are shot across the new growth of the cicatrix so as to completely repair the electro-nervous telegraph, in the order, first of sensation, and then of motion. Thus have we recently learned that a nerve may be cicatrized where it has been divided, and may even be *regenerated* where it has been destroyed; and if aided by favorable circumstances, it will open for itself a new communication when it has been totally destroyed.

First, it must be mentioned, that those paralyses, which Todd, Copeland, Duchenne, and others have called "traumatic," are arranged by Dr. Marshall Hall as "spinal paralysis," and defined by him as that *where the muscles are functionally separated from the spinal cord.* All writers agree that the electro-muscular contractility is diminished in these affections, or even totally lost. Dr. M. Hall assumes that a cerebral paralysis *can* be caused by a disease of the spinal cord; as, for instance,

when the dorsal portion of the cord is injured, the muscles ramified by the nerves that take their origin from that injured portion of the spine present *spinal paralysis;* while the muscles that receive their nerves from any portion of the spine which is below the seat of the injury or lesion, will show us a *cerebral paralysis;* and that because they are merely separated or cut off from the influence of volition, although the affected muscles still remain in their functional relation with the spinal cord. Traumatic paralysis may arise from injury, as severing or *crushing* of the nerve, concussion of joints, or from sprains, or partial luxations.

Paralysis produced by pressure on the axillary plexus of nerves is not of very uncommon occurrence. Frequent examples are seen. Dr. Todd says, "I have seen some cases in which this was produced in the following way: A man gets intoxicated and falls asleep, with his arms, say over the back of a chair; his sleep, under the influence of his potations, is so heavy that he is not roused by any feelings of pain or uneasiness, and when at length he awakes, perhaps at the expiration of some hours, he finds the arm benumbed and paralyzed. It generally happens that the sensibility is restored after a short time, but the palsy of motion continues. Cases of this kind often derive benefit from galvanism; but if the pressure which caused the paralysis has been long continued, then they seldom come to a favorable termination. Nerve tissue is one which *never* regenerates quickly, and seldom completely; so that any great or long-continued lesion of its structure is not likely to be completely removed."

The same high authority gives the following as another example: "This patient is twenty-three years of age; has lived in London, and his right clavicle was broken by an old wall falling upon him. He went to a hospital, (not King's College Hospital,) and the ordinary figure-of-eight bandage was applied. After a time the patient found his right hand and arm were numb; and soon after this he noticed a great loss of power of the extensors of the hand. Notwithstanding these symptoms, the bandage was still allowed to remain, and both the paralysis of

sensation and of muscular motion have continued up to the present time. At present, there are numbness of the hand and arm, and entire loss of power in the extensors of the hand, which are also completely flexed when the arm is raised. All the muscles of the arm have less power than natural."

"This case was treated with galvanism, and the patient left the hospital better; having gained some power in the extensors, and that of the flexors being nearly restored to their healthy state. It was some time, however, before the improvement became so manifest."

Case of Traumatic Paralysis.—Jane B., aged twenty-six, had fallen, in February last, down the stairs in a ship's cabin, and struck the top of her head and the back of her neck. She complained, from that time, of unceasing pain in her head, and presented a complete hemiplegia of the muscles of the left side of the face. By testing the case with electro-magnetic currents, we found that when directed to the palsied muscles of the face, they produced almost no contraction of the muscles, although the intensity of the current was so high as to produce all the pain she could possibly bear. This absence of electro-muscular contraction, in some such instances, is valuable as a guide in diagnosis; for here it indicated the case to be a *traumatic* paralysis of the portio dura. Electrical treatments were, therefore, ventured upon, and, in short, the case entirely recovered.

It is to be remembered, that, in cases of traumatic paralysis, this lost electro-excitability of the muscles and their nerve trunks is found more marked *soon* after the occurrence of the lesion. Dr. Duchenne gives an account of a case of questionable paralysis, in which, from ascertaining the loss of the electro-muscular contractility in the left arm and shoulder, and in the absence of other assignable cause, he diagnosticated a traumatic palsy, from a lesion somewhere in the nerve trunks of that arm. He afterwards discovered an exostosis in the neurilemma which compressed certain branches of the cervical and brachial plexus, which he treated by electro-magnetic currents and other remedies, and so brought about a complete cure.

Case of George K., thirteen years of age, son of an offi-

cer stationed at Charlestown navy yard, fell on his left hand in October, 1858, which broke the ulna, and luxated the radius at the wrist joint. The surgeon attempted to set it, but the boy was wild of restraint, and left for friends at a distance; therefore it was put in some kind of starch permanent splint, where it remained for five weeks. When it was opened a large collection of pus was discharged, all the fingers and hand muscles were closely flexed, and the wrist joint became firm in anchylose; total loss of sensation in fingers. This state of things had continued for three months before he came to me, during which time he had employed liniments and hap-hazard electric applications, from time to time, by the advice of many.

When this patient first took the chair for methodic electric treatment, I found all his fingers, hand, and forearm contracted, stiff, and cold, as if hard wood; anchylosis of hand joints; complete paralysis with atrophy of all the muscles of the forearm and hand, as much so, as in the last stages of progressive atrophy; great pain still about the wrist; neither the primary nor the secondary current could produce the least twitch of the muscles. I therefore applied first a current from thirty Daniell's elements, down-running from the upper and inner side of the arm to the palm of the hand, for five or six minutes, intermitting for a few seconds at every minute. Then I used fifty elements through the wrist for one minute, the positive electrode being placed a little above the wrist on its flexion, while the negative was planted on the back of the hand just below the wrist, so as to direct the current through the whole joint, downward and *outward*. Next, I used the same number of elements on the *extensors* of the hand and forearm for a minute, and then finishing the *seance* with *polar alternatives*, for one minute more, on all the extensor muscles of the fingers, hand, and arm. This, he said, had cleared away the pain, and gave to it the *sensation* of life, lightness, and freedom, although it was still utterly helpless. Much in this manner he was treated daily for a week, when some little motion was obtained — to be continued in like manner another week — from that, astonishing improvement. The powers of motion make their appearance successively; first

the adductors, then the abductors, then the bending of the hand, first by flexion, and then extension; but the crooked fingers remain greatly so yet. Left treatment for the present, while absent at Washington.

In about two months after, this patient came again for treatment; had retained the improvement he gained while here before, and there were new motions appearing about all the hand from the thumb to the little finger; patient, in great courage, and better health. I now instituted a series of *local* galvanic baths, immersing only the hand and wrist, and using forty to fifty elements for five minutes, and in the usual manner: this always produced a prickling and warm sensation, particularly in the fingers, but the effects were not so decided and lasting as were produced by directing the current definitely through given nerves and muscles, or muscle groups. Next, the current was directed especially through the *interossei* and *lumbricales* for ten days; still more life-like appearance, and some more freedom of movements in the fingers; but the wrist continues quite stiff; while, on the other hand, the outrageous and persistent pain in the metatarsal bones is banished; and the boy can open the hand so wide that the inner surface of the hand and fingers can be seen, and he is able to take my hand in his and compress it not a little. His friends were then advised to take him to a surgeon, that he might receive surgical aid while under the influence of ether, for the remaining partial anchylose of the wrist joint. (p. 477.)

Facial Paralysis — Two Classes.

Under the head of *isolated lesion of the nerves*, we have the simple *facial paralysis;* for of all the cerebral nerves, the *portio dura* or facial nerve is the one far more frequently attacked with palsy than any other. The first thing to be done here is to diagnosticate this simple affection of the facial branch of the seventh pair, (which is also called the portio dura,) from that other paralysis which in most respects resembles this, but which is rather a symptomatic disease of actual brain lesion. For this reason we must set out with the distinct understanding that

there are two very different kinds of facial palsy; the one arising from a *sudden* cooling, and hence neuralgic, or from the severe local or protracted exposure to cold, and hence rheumatic; or it is due to pressure somewhere along the bony exit of this nerve trunk, after its exit from the cranial cavity, as from a tumor or exostosis of bone, or from a syphilitic or scirrhous deposit in its sheath; or it may arise from a neighboring bony caries and consequent suppuration; the other form — the symptomatic and grave kind — arises from an intra-cranial origin.

Now, we will observe, first, in regard to this latter type of the disease, which arises from a brain origin, or from some injury to the intra-cranial portion of the seventh nerve, that we usually get some characteristic difference in the symptoms, as a loss of taste, with a numb sensation in the side of the tongue, caused by some intercepting influence that cuts off the physiological function of those nerve fibrils which come from the *chorda tympani;* there is also a difficulty of deglutition from paralysis of the *digastricus* and *stylo-hyoideus;* the hearing is affected, and the uvulva hangs towards the sound side; and in some cases, although the patient can move the tongue, yet there is not the ability of *covering* the upper lip with it, so that its tip shall reach the septum of the nose. Wherever the tongue and the pharynx are involved in the paralytic affection, it should put us on our guard, as being indicative of some mischief in the brain. But the most distinctive characteristic difference between the two kinds of facial paralysis is, that *a paralysis of the orbicularis palpebrum does not occur in a facial hemiplegia of a central origin.* Therefore, *if the eye cannot be shut*, we may rest assured that the case is one of simple paralysis of the facial nerve, and is suitable for treatment. It is worthy of notice, that the grave symptoms of a lost taste, difficult deglutition, and deviation of the palate *may possibly arise from poor dentistry plate work*, such as is sometimes worn as temporary. The author has seen several such instances, and some of them very serious indeed, being of long standing. But it should be known that these are generally amenable to the so-called localized use of electro-magnetism. But let us notice what further *is not* the simple paralysis of the *portio dura* or facial nerve.

1. If the *motor oculi*, or third nerve, be paralyzed, as it divides into two branches and enters the orbit between the two heads of the external rectus muscle, the superior branch ascends and supplies the *superior rectus* and *levator palpebræ* muscles, the eyelid, particularly the outer angle, cannot consequently be raised, from loss of power in these two muscles; and this constitutes *ptosis*. There is also in such a case a protrusion of the eyeball, which cannot be turned inward, and at the same time the outward lateral movement of the eyeball is not impaired, since the *rectus externus* is supplied by the sixth nerve; there are also a marked dilatation of the pupil, double vision, and only a *distant* sight, i. e., it is next to impossible for the patient to adjust the eyes to see objects close by.

2. If there is a paralysis of the fourth nerve, (*pathetici*,) the symptoms are but slight. The patient experiences some double vision, when looking on a level; and to avoid it, the face is carried rather to one side, and that the sound side. When looking upward, the sight is not much disturbed, because the affected pupil is turned a little upward and outward.

3. If the *abducentes* (sixth nerve) be paralyzed, then the patient has "*converging strabismus*," or inward squint, and is also troubled with a double vision when looking in certain directions, and this in proportion to the extent of the affection. If it occurs in connection with the paralysis of the third nerve, as indeed it often does, then the eyeball is immovably fixed, it being drawn forcibly towards the nose, so as to cover the whole cornea at the inner angle of the eye.

These three paralytic affections of the eye *may* arise from brain origin, but not necessarily so. There may be pressure on the trunk of either of those nerves that are affected; but the trouble is supposed to arise more frequently from a rheumatic or syphilitic exudation on the sheath of the nerve, or from an over use, or very deficient use, of the eye muscles. For these cases, where not positively contra-indicated, I am in the habit of employing either Faradaic or Galvanic currents directed locally to the muscles involved, for two or three minutes, always closing the *seance* by "*washing*" the whole face and neck with just bearable

induction currents, and that by ceaseless *labile* movements, for one or two minutes more, using large, soft, wet sponge electrodes. The tip of the finger of the operator, or the two small sponge-tipped ivory electrodes, are best for conveying the current to the affected muscles. Dr. Meyer, of Berlin,* has recently treated some of these cases successfully, by electricity. He placed the negative pole of electro-magnetism in the hand of the patient, and then employed a very small, moistened sponge as the *positive* electrode, which he applied directly to the skin of the closed eye, as near as he could to the paralyzed muscles. For reaching the *rectus internus* he held this electrode to the inner angle of the eye; and for the muscle *obliquus superior*, he placed it beneath the *trochlea*. He thus treated, it appears, a patient for Dr. Von Graefe, who had been afflicted for five months with double vision, from a paralysis of the *rectus internus* and *obliquus superior*. Dr. Meyer treated another case that had suffered for some four years with double vision from paralyzed muscles of the eye, in whom he effected a complete cure in six weeks, by electricity. The author would recommend great care in attempting to employ Galvanic or Faradaic currents about the eye. It is probably more wise and prudent to employ first the *labile* induction current in all these cases, and that moderately; but still do I know that the former can succeed, where the latter may fail. (See pp. 231, 266, 641, and Appendix D, Note 3.)

Paralysis of the Facial Nerve, (Portio Dura.)

There are, then, *two kinds of facial* palsy. The one kind we have just been examining and treating. But the true and simple paralysis of the portio dura, in whole or in part, but outside of the cranial cavity, and hence most suitable for electric treatment, is characterized and known on the one hand by *the want of power over the eyelids*, so that the eye cannot shut by the action of its own muscles; and on the other, *as not* attended with loss of taste, nor is there numbness in the tongue, nor difficulty of swallowing bread. When this face affection comes on

* Deutsche Klinik, 1856, No. 38.

from exposure to a draught of cold air, as from a car window, it is then more generally of a rheumatic character; and hence some of the muscles are affected more than others; and some of them also recover sooner than others. The absorption of the rheumatic effusion is sometimes spontaneous, at least to a degree. In all these cases the electric currents are found to be decidedly the most effectual means for restoring the muscles to their healthy state and physiological action. If the facial paralysis is complete, then all the expressions of the physiognomy flat out; i. e., on the paralyzed side, but are exaggerated on the sound side. But if both sides of the face should be similarly affected, then the countenance of the individual is totally changed. Nor is he able to laugh, frown, or whistle — or only on one side, if but the other is affected. In that case, the palsied side appears bloated, pouting, and drawn around towards the sound side. But as this nerve is the motor for nearly all the muscles of the face, let us examine the effects of its partial palsy. (See pp. 266, 432, and D.)

Where there is a paralysis of the muscle *orbicularis palpebrarum*, which is depending on the *portio dura*, as we have said, the eye cannot be closed; the eyeball is all the time exposed to the air, even during sleep, and consequently the conjunctiva is liable to become injected or inflamed. In that case the tears flow freely over the cheek, and sometimes so acrid are they that they excoriate the skin of the face. The eyelids are kept open, because the antagonizing muscle (*levator palpebræ superioris*) *is not* depending upon the *portio dura*, but is animated by the third nerve. On the contrary, where the third nerve is palsied, the eye is *shut*, and cannot open of itself. But in facial palsy, when the patient is requested to shut the eye, if any motion is perceptible at all, the ball of the eye is only turned upward and inward, but the eye does not readily or completely close. The eye appears staring and somewhat protruded, showing considerable of the *sclerotica*, which is mostly due to the dropping of the outer portion of the under eyelid; but there is no such evidence of *deficient nutrition in the cornea and conjunctiva*, as observed in cases where branches of the fifth (tri-facial) nerve are paralyzed; and if the fifth nerve be the one paralyzed, then

there is *anæsthesia also* of the face, and that perhaps *without* the loss of motion, because the fifth is mostly a nerve of sensation.

Again, if the *corrugator supercilii* muscle, and the anterior portion of the broad *occipito-frontalis* muscle are paralyzed, — for they are depending on the portio dura, — then the forehead is smooth — and cannot be wrinkled; nor can the patient frown. The transverse wrinkles depend upon the first-named muscle, while the perpendicular wrinkles, as seen between the eyes and over the nose, depend upon the *corrugator*. In extreme cases of such paralysis, the eyebrow drops so as to hang over the eye-ball, and give the countenance a most doleful appearance.

If the twin *zygomatici* muscles, together with the *levator anguli oris* are paralyzed, as they too are animated by the portio dura, then that angle of the mouth is greatly depressed, and the whole mouth is drawn to the opposite side; but on the sound side the corner of the mouth appears to be higher, and drawn upward towards the ear. On the palsied side the corner of the mouth gives the fullest expression of pouting.

If, then, the muscle *orbicularis oris* is paralyzed, it is shown by the patient being unable to purse up the mouth, or to whistle; the lips are drawn and stretched by their sound end far back towards the ear on the sound side, allowing a drooling of the saliva, and greatly preventing labial pronunciation.

If the deeper and larger *buccinator* muscle be paralyzed, — for this, too, is depending upon the portio dura, — then that cheek will appear remarkably bloated, flaccid, and old. And during respiration the cheek is then seen to be unable to resist the outward and inward pressure of air, and hence the breathing is sometimes *stertorous* in some degree, much as it is in apoplexy when this condition obtains on both sides during the fit. The power of biting is not much impaired, for the very good reason that the *masseter* and *temporal* muscles are not depending upon the *portio dura* nerve; but the process of eating is awkward and troublesome, because the food accumulates between the cheek, the teeth, and gums.

And again, if the *levator alæ nasi* and the *pyramidalis* are paralyzed, then the nostril on that side is deprived of voluntary motion, and the nostril is retained open only by the elastic fibre of its structure. Hence the gentle waving motions in the sides of the nose during respiration are lost, or *exactly reversed;* i. e., in health the nostrils are dilated during inspiration, but in facial palsy this is noticed as occurring during expiration. In the horse this would be a fatal affair if it occurred on both sides, as his nostrils are very soft, and kept dilated by the action of the *portio dura.* When this nerve is severed in the horse, his nostril flaps together, and the more violent the inspiration, the greater the collapse of the nostril. As the horse breathes only through his nose, he must die of asphyxia if the facial nerve is either severed or paralyzed. So also, if the *portio dura* is severed in the ass or rabbit, the ears drop and become hideously deformed, because they are soft and long ; but no such abnormal symptoms show themselves in man from an actual paralysis of those branches of the *portio dura*, that in the human organism also ramify the external muscles of the ear, because the human ear is kept in its normal position by its partial structure of elastic fibre. And this completes the list of the prominent symptoms of facial paralysis, which may be seen occurring either together or separately, being caused by *a palsy of the superficial branches* of the *portio dura* or facial nerve.

To recapitulate : if the *trunk* of the *portio dura* is injured in its *intra-cranial portion*, then we do not see the above *isolated* symptoms, but, they would then be general and uniform ; and not only so, but as we have seen, there are collateral symptoms from the eighth nerve, as it also is involved ; there are loss of taste, and a sense of numbness in the tongue, caused by palsy of the *corda tympani.* There is also difficulty in swallowing, from the paralysis of the *digastricus* and *stylo-hyoideus* muscles ; the uvula is drawn to the sound side, and the tongue *protrudes to the sound side and downward;* and the hearing will be affected, and perhaps attended with very peculiar noises in the head.

The *deep-seated* palsying effects on this great nerve trunk

may arise from otitis, caries, and necrosis of the petrous portion of the temporal bone, or from sanguinary congestion, or inflammation of the nerve sheath, &c., and this may sooner or later extend to the brain, according to the nature of the solution of continuity. Some such results we see soon followed by more grave symptoms, or even death. Other rare cases, after a time, appear to be attended with an irritative inter-cranial cicatrix, and hence there sets in a rigid and permanent contraction of some of the muscles of the face. It is obvious that any electrical treatment here is both useless and hazardous. But in others it happens that after this grave paralysis has continued for a considerable time, the whole set of affected muscles take on a shade of improvement. And here we may find now and then a person we can save, by bringing electricity as a timely aid, if employed prudently, but perseveringly, and that with other rational treatment. There is the best of testimony that such recoveries are not rare, even after a half dozen or dozen years' standing.

Dr. Duchenne lays down the *rule* that whenever the paralyzed muscles of the face, which give a pouty cast to the features, also respond "*very sensitively*" to electro-excitement, by such prompt contractions as show that their excitability remains intact or is exalted, it is evident, according to this experience, that the facial hemiplegia is due to a true cerebral source. But if the muscle *orbicularis* of the eyelid is paralyzed, and on the other hand if the muscles *do not* so respond to the electric excitement, we may then be quite certain that the facial hemiplegia cannot be referred to a brain origin and source. In this latter case the affection arises from a pathological *state* of the facial portion of the seventh, or *portio dura*, nerve. He speaks of having repeatedly cured cases of paralysis of the tongue and face by the means of Faradaic currents.

As regards the number and length of the treatments *for such cases as where we are not quite certain* as to their nature or state, it is thought most wise not to make the *seance* so long or so thorough; and if not restored, after some ten to fifteen treatments, it had better be omitted; and after some delay, it can be again repeated. (See pp. 240, 266, and Appendix D, Note 3.)

Lead Palsy.

Lead paralysis is an accident most likely to occur in persons working in *lead* or its compounds, as painters, compositors, plumbers, lead-pipe workmen, and the hands in white-lead manufactories. It may and does occur frequently from drinking *made*, or *adulterated*, liquors or wines, fixed beer, or from taking quack medicines, and clandestine prescriptions. Thus some drink the saturnine poison, others inhale it, while others are affected by handling it. An impure, or rather an impregnated water, as with acid, iron, or salts, if conveyed through leaden pipes, may also cause lead palsy. I believe, in fact, that a *taint*, or *predisposing state*, may be not unfrequently imbibed with drinking water that has lain in, or flowed through, lead service pipes.

When the blood of a person has become to any great degree contaminated with lead, then there are produced various abnormal symptoms, and these are usually in the following order: first colic, next cramps, then neuralgia or amaurosis, and then the "*dropping of the wrist.*" These are the first prominent symptoms of lead palsy. The extensor *muscles* of the upper extremity, and most generally those only of the right forearm, are most liable to show it first; and these same finally suffer the most wasting. All the joints of the fingers are not equally affected. It is the first phalanges that cannot be extended; while the power of motion in the two last phalanges of the same fingers is not impaired. This is because the *interossei* muscles are very rarely affected by lead. The paralysis soon extends up the arm, and we find even the *triceps* and the *deltoid* suffering the loss of substance and power. The electro-muscular contractility is then much diminished, and in a short time is utterly lost. After that occurs, wasting goes on rapidly.

But this ruinous result should be avoided, as indeed it can be, by an early and efficient resort to electro-therapeutics, as this is the most potent remedy for lead palsy now known to the healing art. We notice that M. Tauquerel-des-Planches reports that out of one hundred and thirteen cases of lead palsy, ninety-three cases had this palsy in the arms, fourteen in the lower

extremities, and six as extensive or general paralysis. All authorities agree that electricity should be resorted to in cases of this kind, in connection with the internal use of the iodide of potassium, and even if late, as where there is no response by contraction of the affected muscles to the electric stimulus, and where the size of the muscles is already considerably diminished.

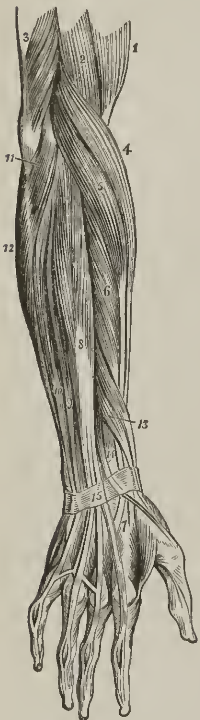

Fig. 89. A View of the Muscles on the Back of the Forearm, (Extensors.)

Case of Lead Palsy — Electro-Excitability of the Muscles gone, (taken from case-book.) — William Kittridge, of New York, had for several years worked in the Brooklyn White Lead Works. He is thirty-eight years of age. He has had repeated attacks of lead colic, for which he was always promptly attended by the best of medical skill. As he was an important workman about the works, he was always amply cared for. He is sent on to me by his employers. He does not stand erect; has dropping of both the hands, and decidedly stoops as he attempts to walk. He appears dejected in countenance, voice, and movements. His pulse is sixty; bowels are obstinately constipated. When the hand is placed on the abdomen the parieties appear contracted and hard. A blue line is distinctly visible near the edges of the gums, but about only *some* of the teeth. The

1. Lower Portion of the Biceps Flexor.
2. Part of the Brachialis Internus.
3. Lower Part of the Triceps Extensor.
4. Supinator Radii Longus.
5. Extensor Carpi Radialis Longior.
6. Extensor Carpi Radialis Brevior.
7. Tendinous Insertion of these Two Muscles.
8. Extensor Communis Digitorum.
9. Portion of the Extensor Communis Digitorum, called the Auricularis.
10. Extensor Carpi Ulnaris.
11. Anconeus.
12. Portion of the Flexor Carpi Ulnaris.
13. Extensor Minor Pollicis. The Muscle nearest the Figure is the Extensor Ossis Metacarpi Pollicis.
14. Extensor Major Pollicis.
15. Posterior Annular Ligament. The distribution of the Tendons of the Extensor Communis is seen on the Backs of the Fingers.

whole right arm appears to be nearly paralyzed, even to the shoulder, although he can hold a cane in his hand. If the arm and hand are rested on the table so as to extend the first phalanges, and thus allow the second and third phalanges to extend over the edge of the table, he has all needful power to move, extend, and contract the second and third phalanges; and this is evidence that the *interossei* and *lumbricales* have not been involved. In the left, this is in less degree. The voluntary lifting of the arm from the table, he finds, is difficult; but the extending it out horizontally is quite impossible. The back of the forearm is fairly concaved from the wasting of the extensors. The flexors of the arm are not in the least affected, but the deltoid is diminished certainly one half. Upon his taking the operating chair and receiving the electrodes of one-inch metal balls covered with wet wash-leather, the one being placed over the nerve *ulnaris* and the other over the wasted muscles, no kind of contraction could be produced by the strongest electro-magnetic currents. But he continued to receive electric treatments twice a day for twelve days, when it was noticed that not only the withered *deltoid* muscle showed some excitability, but also the wasted extensors of the forearm began to swell with fluids, became warmer, and showed some signs of muscle fibre contractions. The treatments from this time were had daily for ten days more, accompanied with shampooing and automatic movements while at home; and these latter were also repeated several times a day. The patient received from this time also at every *seance* the primary current of galvanic electricity, from twenty to thirty Daniell's elements, as part of the treatment; using the Faradaic currents first, and then the Galvanic, — in all not more than from five to ten minutes at each *seance*. Not only the *labile* method, but also *metallic reversings* and *polar alternations* were employed, so as to produce muscular contractions if possible, and to cause greater capillary circulations. At the end of these ten days it was very noticeable that the warmth, growth, and strength of the palsied and wasted muscles of both arms had returned faster than in the twenty days previous; and, to my mind, the

alternate electricities produced from second to second, or every five seconds, had done much, by reflex action, towards restoring the muscles to an obedience of the will. The electrical treatments were daily repeated for some three weeks more, when Mr. Kittridge returned home, and, as he says, in writing to me since, "good as new."

Rule. — In lead palsy we may always expect to find a more or less *diminution* or *loss* of electro-muscular contraction; therefore, in doubtful cases, where the muscles of a paralytic limb simulates lead palsy, yet contracts promptly or decidedly as response to the electro-magnetic or magneto-electric current,

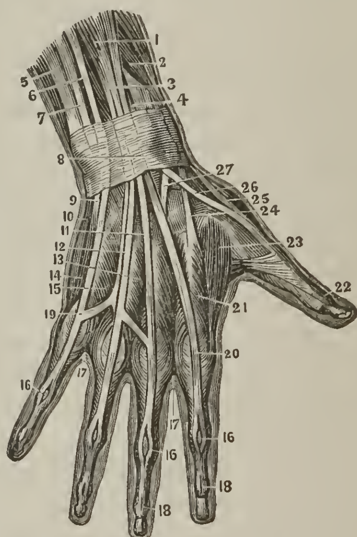

Fig. 90. A View of the Muscles and Tendons on the Back of the Hand.

1. Lower Portion of the Extensor Communis Digitorum.
2. Extensor Minor Pollicis Manus.
3. Tendons of the Extensor Communis.
4. Extensor Major Pollicis.
5. The Ulna.
6. Tendon of the Auricularis.
7. Extensor Carpi Ulnaris Tendon.
8. Posterior Carpal Ligament.
9. Insertion of the Extensor Carpi Ulnaris into the Metacarpal Bone of the Little Finger.
10. Adductor Minimi Digiti.
11. Middle Tendon of the Extensor Communis.
12. Tendon of the Ring Finger.
13. Prior Annularis.
14. Flexor Parvus Minimi Digiti Manus.
15. Interosseus Digiti Auricularis.
16, 16, 16. Arrangement of the Extensor Communis Tendons at the Phalangial Articulations.
17. Points to the *Interossei* Muscles on the Back of the Hand.
18. Insertions of the Extensor Communis.
19. Cross Slips connecting the different Tendons of the Extensor Communis.
20. Tendon of the Indicator.
21. Prior Indicis.
22. Insertion of the Extensor Major Pollicis.
23. Abductor Indicis Manus.
24. Insertion of the Extensor Carpi Radialis Longior.
25. Extensor Minor Pollicis Tendon.
26. Extensor Major Pollicis Tendon.
27. Insertion of the Tendon of the Extensor Carpi Radialis Brevior.

we may fairly conclude that in such a case *lead is not* the cause of the attack. The electric current is here the only reliable diagnostic test. (See p. 478, Note C, and Appendix.)

Dr. Duchenne admits, it is true, that the deeper strata of muscles, which are covered by the superficial muscles, will not exhibit electro-muscular contraction from *direct* Faradaization; but as atrophy diminishes the superficial muscles earliest and mostly, he has been thus helped to the knowledge of the physiological function of every muscle in the living body. I may mention, in this connection, as one of the most remarkable facts quoted by recent writers, viz., it is found that the muscle *extensor communis digitorum* has no influence whatever on the extension of the second and third phalanges, as generally thought, but only on the first; that it is in fact the small *interossei* that extend the second and third phalanges, while the *lumbricales* bend the first phalanx; that the *flexor sublimis* and *profundus* muscles bend the second and third phalanges, but not the first. Pathological facts have also demonstrated this, as in cases of lead palsy and muscular atrophy. We find in cases of lead palsy that the *extensor digitorum* situated on the back of the forearm is palsied, and perhaps atrophied also; but the affection does not reach the *lumbricales* and *interossei*. In lead palsy, therefore, the capability of extending the second and third phalanges remains normal; it is only the first set of phalanges that cannot be extended, and this gives the characteristic "*dropped hand*." On the contrary, if there is paralysis, and perhaps atrophy too, of the *interossei* and *lumbricales*, while the *extensor digitorum* is not at all paralyzed, as in "wasting palsy," or after some severe sickness, then the fingers present the appearance of *claws;* the hand is extremely lean, and the interosseous spaces are deeply hollowed out. Here we see the first phalanges *can be* extended and contracted at will; but the second and third phalanges are *constantly* bent. This is the reverse of what takes place in lead-palsy, and is a diagnostic sign between wasting-palsy and lead-palsy.

Rheumatic Paralysis.

Persons suffering from various degrees of this affection constitute, to my mind, a class of most interesting and yet deplorable cases. The individual is not sick, and yet there is this insidious process of limb-distorting; and that, perhaps, in the very prime of life, for while the limb or joint is becoming more and more enlarged, contracted, or atrophied, it is also more and more painful and helpless; and if not early arrested, the limb is far worse than lost, because it is useless, painful, and cumbersome. I have often asked myself if of such could have been the "palsied" and the "withered" hands, and feet, and limbs of those who applied, and not in vain, to the kindliest heart that ever pressed our earth — to Christ, the great Physician who but spake, and they were restored. Now, too, under the accumulating blessings of divine Prov-

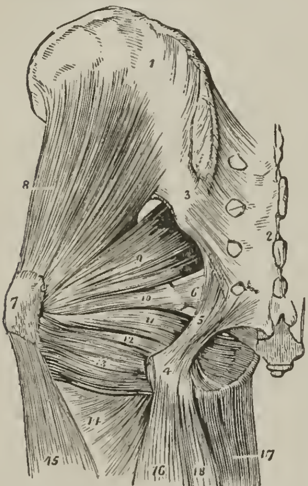

Fig. 91. A View of all the deep-seated Muscles of the Hip-joint, the Gluteus Magnus being removed.

1. Os Ilium.
2. Os Sacrum.
3. Posterior Sacro-Iliac Ligament.
4. Tuber Ischii.
5. Greater Sacro-Sciatic Ligament.
6. Lesser Sacro-Sciatic Ligament.
7. Trochanter Major.
8. Gluteus Minimus.
9. Pyriformis. From under this Muscle the Great *Sciatic Nerve* makes its exit from the great Sacro-Sciatic Foramen, and in its passage down, it rests upon Figures 10, 11, 12, 13, and 14, and is covered only by the Gluteus Maximus at this point; but farther down is covered in by the Biceps, Semitendinosus, and Semimembranosus.
10. Geminus Superior.
11. Obturator Internus.
12. Geminus Inferior.
13. Quadratus Femoris.
14. Adductor Magnus. The *Electrode* should be placed in the space bounded by 7, 3, 4, 16, and 15, to cover and best reach the Great Sciatic Nerve. For Electro-Puncture, the spot for inserting the insulated *Gold Needle* is at 14.
15. Vastus Externus.
16. Biceps.
17. Gracilis.
18. Semitendinosus.

idence, we have the means of power put into our hands that can reach and restore not a few; for it may well be said, that for these, electro-therapeutics cannot be replaced by any other known remedy, except the miraculous. I have had under electrical treatment a large number of cases of rheumatic paralysis, and many with deposits, contractions, and atrophy; and those of all stages, from the earliest symptoms of numbness, stiffness, and pains, to the older and atrophied cases with pseudo-anchylose and rigid contractions. Of these, my case book shows a very credible amount of restoring good accomplished, and that mainly by the power of Galvanic and Faradaic treatment. But the ratio of cures — of time to produce the cure, (I mean *a rheumatic cure*, which is an approximation to complete restoration, with some liability to recurrence,) — this, in each case, is found to be *nearly* in proportion to the length of time the case had been existing, but precisely in ratio with the degree of tonic contraction and atrophy. But where the wasting is moderate, the anchylosis is still a little flexible, and hence not complete, and the tonic contractions as yet are not great, or even if these all are extreme, but the case is *recent*, then there is the greatest probability that a well-directed and persevering methodic use of electro-therapeutics will solve out the whole difficulty. And even in the older cases of *rheumatic* muscular atrophy and paralysis, the methodic

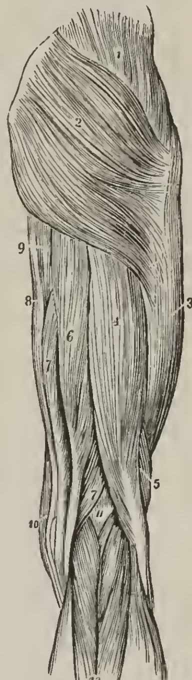

Fig. 92. A View of the Muscles on the Back of the Thigh.

1. Gluteus Medius.
2. Gluteus Magnus.
3. Fascia Lata covering the Vastus Externus.
4. Long Head of the Biceps.
5. Short Head of the Biceps.
6. Semitendinosus.
7, 7. Semimembranosus.
8. Gracilis.
9. Edge of the Adductor Magnus.
10. Edge of the Sartorius.
11. Popliteal Space.
12. Gastrocnemius.

use of electricity is often of the greatest service in lessening the pains, loosening the rigidity, and warming the part with more vital action, so as to retard or stop this ruinous rheumatic process.

Persons who labor or stand *in cold with damp*, and particularly if they have a rheumatic diathesis, are candidates for this affliction. Hence the washerwoman, fisherman, the ditcher, stall-tender, well-digger, or those who work in cellars and drains, are the most liable to this form of rheumatism. Out of seventy carefully recorded cases, thirty-three were traced to these classes. They were mostly ultimate cases of paraplegia, some complete, some partial; and what is remarkable, the partial cases had, almost to an individual, a previous history of acute sciatica. Some others were affected in the right forearm, wrist, and hand; and this, in one instance, in connection with the affection also in the right lower limb; in another it was in the left limb.

In-door mechanics and seamstresses make another class that very frequently present with local paralysis, and with as well marked evidences of rheumatism; and yet the affection in them is not only paraplegic, but is almost invariably at the same time affecting the *deltoid* and other arm and shoulder muscles, *or these latter exclusively*. In three cases it gradually produced sub-luxation of the head of the humerus. Are these

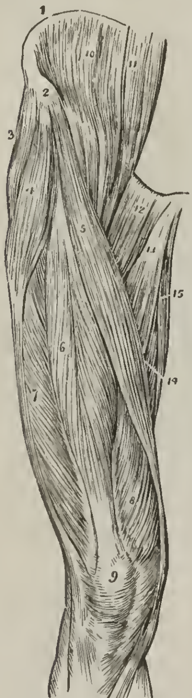

Fig. 93. A View of the Muscles on the Front of the Thigh.

1. Crest of the Ilium.
2. Its Anterior Superior Spinous Process.
3. Gluteus Medius.
4. Tensor Vaginæ Femoris.
5. Sartorius.
6. Rectus Femoris.
7. Vastus Externus.
8. Vastus Internus.
9. Patella.
10. Iliacus Internus.
11. Psoas Magnus.
12. Pectineus.
13. Adductor Longus.
14. Adductor Magnus.
15. Gracilis.

latter cases of the progressive, wasting palsy, or rheumatic palsy, or are they cases partaking of the character of both these?

Where there is this morbid affection of muscles and joints, I find that a *stabile* strong current led steadily through the *neighboring* muscles also, sometimes on this side and then on that, for a whole minute at a time, and that, for five of the fifteen minutes at each seance, has most decidedly beneficial effects on the contiguous diseased muscles and fascia, and on that joint that is affected and situated below or beyond the site of such procedure. Then let the current be passed from large and soft electrodes, transversely, or rather *obliquely* through the diseased joint from minute to minute, with a recess of only a few seconds between each application.

Fig. 94. A View of the Muscles on the Front of the Leg.

Case. — Mr. C., twenty-five years of age, a lawyer, had a chronic swelling, with stiffness, and at times inflammation of and about the elbow joint, with contractions of the muscles that kept the arm and hand at a right angle, and it was nearly paralyzed. It was tender to touch, smooth, red and somewhat hot, was stiff and painful continually. I placed the elbow on a broad plate electrode, three inches in diameter, that was covered with a soft thin sponge and laid upon the table, upon which his arm rested. This was connected with the *negative* pole, while the *positive* was placed on the outer and upper muscles of the joint, and thus, at first, a scarcely perceptible current of thirty Dan-

1. Tendon of the Quadriceps Femoris.
2. Spine of the Tibia.
3. Tibialis Anticus.
4. Extensor Communis Digitorum.
5. Extensor Proprius Pollicis.
6. Peroneus Tertius.
7. Peroneus Longus.
8. Peroneus Brevis.
9, 9. Borders of the Soleus.
10. Portion of the Gastrocnemius.
11. Extensor Brevis Digitorum.

iell's element was passed through the joint obliquely for five minutes, during which the positive pole was moved from minute to minute, from place to place about the joint, but always on that same side of it. The tension was immediately diminished. I then produced some twitchings of the extensors of the forearm, and then those of the arm muscles, by the current changer. All this had good effects — less red, but joint still hot; omit for three days — heat then less, and much improved, but pain still in the bend of the elbow. This was entirely removed in the course of a few more sittings. In four weeks this treatment most radically cured it, and restored the arm nearly as well as the other. (See p. 475, A, B, C, and Appendix E, F, G.)

"*Spasmo-Paralysis*" *in Childhood.*

Dr. W. J. Little, the "founder" of the Royal Orthopedic Hospital near London, gives an *exposé* of his views of early and "unnecessary division of tendons" in children under ten years of age, who are suffering from spasmo-paralysis.* We cannot do better here, than to quote such candid and practical advice. He there says, "I shall endeavor to demonstrate, that the larger portion of those contractions of muscles, which take place during childhood, may be treated *without* tenotomy; at least as successfully without division of tendons, as with the performance of that operation."

In order not to appear to disparage Stromeyer's great discovery of sub-cutaneous division of tendons, and to prevent misconstruction, I may at once state, that many cases of non-congenital deformities in various parts of the body and limbs, in their *advanced stages*, are relievable *only with the aid* of such tenotomy. Talipes equinus, wry-neck, contracted elbow and knee, when severe, and of several years' duration, may be here adduced. But it is now a matter of weekly experience to me, how singularly the necessity for resort to the tenotomy becomes restricted, when mechanical treatment by means of properly adapted and adjusted apparatus and manipulations, *aided by physiological*

* Braithewaite's Retrospect, for 1858, part 37, page 132.

treatment, are philosophically resorted to. Having been in the first instance exclusively instrumental in removing the treatment of deformities, as a rule, from the hands of instrument makers to those of the members of the medical profession at large, and that with great advantage to the public, it will not be imagined, by restricting the performance of surgical operations to fewer cases than it has of late years been applied to, that I propose again to delegate the treatment of deformities to the instrument maker. On the contrary, I am more and more fully persuaded that the proper contrivance, selection, and even the application of a mechanical instrument *can only be judiciously effected by the medical man*, who is properly versed in anatomy and pathology, or at least under *his* immediate supervision.

In early life, from certain but not very clearly defined forms of disease, involving parts of the cerebro-spinal system, one set of muscles in a member may lose the power of contracting, and become relaxed, or even paralyzed, whilst the antagonist muscles more or less speedily manifest a disposition to contract; or else that the muscles on both sides of a member, (flexors and extensors,) without any distinct paralysis in this case, lose something of their power of acting under the will. A state still more often occurs of half paralysis and half spasm, to which the late Dr. Marshall Hall, first, I believe, applied the term "spasmo-paralysis," the consequence of which is, that the stronger set of muscles, commonly the flexors, acquires a preponderance, contracting the limb in the direction of their action, and that more usually occurring in the leg.

To such causes, partial paralysis and spasmo-paralysis — the majority of the contractions of infancy and childhood — owe their origin. If the *tendency* to contraction be borne in mind by the medical attendant, its prevention may be effected. If the contraction be discovered when nascent, its further progress may be interrupted by suitable treatment, viz., attention to nutrition, and the general health, especially to the condition of the alimentary and nervous system. This is aided by *local remedies*, such as adequate covering of the part, in order to maintain, if possible, a proper temperature — (I say, *this must be done*) — also,

by periodical manipulations, so as to insure the limb being thoroughly put through all its natural movements daily, once at least, or oftener; and by a studied use of the member, so as to favor relaxation, or coerce elongation of the contracted parts, and to acquire strength in those of that set which are weakest.

By the use of such means, it is my experience, the greater number of paralytic or spastic contractions that are acquired during childhood and adolescence (growth) may be obviated or arrested from being worse; the exceptions being cases in which a more than usually severe paralysis, or an active tonic spasm, affects some or all of the principal muscles.

Mark, — so long as the medical practitioner has simply to do with paralysis or spasm, and an amount of contraction *susceptible of yielding to the pressure of the hand*, or even to the moderate use of some comfortable mechanical contrivance, calculated to maintain the member by times in a proper position, the rational surgeon will not affirmatively entertain the question of "division of tendons;" for, surely, the *division* of muscles affected with paralysis, or with spasm, is no cure for these diseased states. Indeed, in many instances the contracted muscle is a healthy muscle, shortened merely from want of action in its antagonists; and it is certainly inconsistent with sound therapeutics to endeavor to reduce by tenotomy a healthy muscle to the equal condition of a paralyzed one.

Moreover, the apparent benefit derived from division of the tendon of a muscle, itself being healthy, but possessing an inconvenient activity, *is only temporary;* for after a few months' time, the muscle (in children) *re-contracts*, unless the practitioner has determined to prevent the healthy muscle recovering tone after its division, by sedulously keeping the ends of the divided tendon as far as possible asunder — an effort often frustrated by nature, causing *slow* contraction in the newly-interposed or uniting medium. Instead of operating by tenotomy, in such cases, we are bound rather to exhaust all legitimate modes of counteracting the paralysis; remembering that during childhood and growth, there is ever hope of at least partial recovery from the paralysis. But when the case may be justly

termed "incurable," then, even, mechanical supports, by means of elastic substances, steel springs, or rubber, may aid the weak member to perform its office.

It has so often happened, that while such a patient has been under treatment, by *tenotomy* and the subsequent mechanical treatment, say during a period of ten or twelve weeks, or months, that the paralysis of the non-divided muscles has partially or wholly disappeared, justifies the opinion that the same period occupied by proper treatment, *without* the preliminary tenotomy, would have equally witnessed cessation of paralysis, and consequent cessation of the contraction and deformity, by the restoration of antagonistic and associated muscle-action of the respective parts. That this result would have ensued, is not merely an opinion, but a matter of observation, in similar cases treated without tenotomy.

Until the age of ten years, varying according to constitution and growth, the majority of paralytic and spastic muscle contractions may be subdued by mechanical and other physiological means. As after preliminary tenotomy, the same mechanical means and physiological treatment are here for an equally protracted period desirable; i. e., until recovery from the paralysis or spasm takes place. Unnecessary tenotomy has not really the merit of even saving time; for although, *at first*, a rapid alteration of the form or mobility of the affected muscles and articulation is produced, which operates very favorably on the minds of the bystanders and friends, it after all is often an ultimate delusive benefit; often acting injuriously also by detracting attention from the other important modes of treatment. The *division* of tendons in paralytic contractions and spasmo-paralytic contractions is indispensable, when the contracted muscles have undergone *structural shortening* — a state in which, besides constant contraction of collective muscle fibres, whether resulting from loss of antagonism, or from spasm, (tonus,) the individual muscular fibres, after the lapse of several years, probably not less than six or seven, — more rapidly, however, during childhood than after puberty, — have undergone an interstitial change, the nature of which is imperfectly known, appar-

ently consisting of adhesions amongst themselves, degeneration, atrophy, and adipose transformations, which render the aggregate muscle incapable of elongation by ordinary moderate mechanical extension. This state of "structural shortening" of muscle may be known by the long duration of the contraction; by the sensation of *rigid*, inelastic, cord-like resistance that is offered to the hand of the examiner; and by the shrunken, wasted condition of the muscles, volition not necessarily being entirely absent in such.

Those who are familiar with the physical condition of the parts concerned in deformities have no difficulty in recognizing when *structural shortening* of the given muscles does or does not exist. I would suggest to those who are not adepts, that if, after employing as tests the signs which I have enumerated, they still remain in doubt, they may, when there is no objection to anæsthesia, subject the patient to the influence of ether inhalation. During the insensibility, a contracted joint always becomes flexible, i. e., so long as structural shortening does *not* exist. But if the muscular fibres have actually undergone interstitial degeneration and shortening, the joint then will not be bent or extended without violence and laceration of fibres. Fig. 95 shows "Drake's Spinal Apparatus for Curvature," and "Drake's Apparatus for Paralyzed Limbs," and particularly adapted to cases of *spasmo-paralysis in children*, both retaining the withered and contracted limb in place, and at the same time enabling the patient to exercise, and even walk,

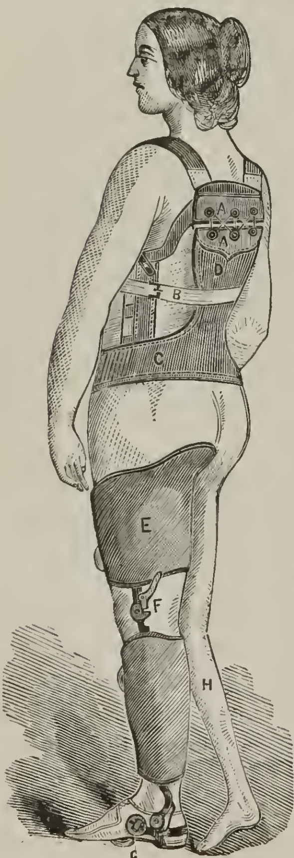

Fig. 95.

earlier than otherwise. The figure gives a view of the *spinal supporter* as when applied and worn over the under linen. A A marks the part of lacing that can be adjusted so as to support the most projecting part of the back. B is the adjustable strap that connects the bars that support the shoulder. C is the steel base of the spinal support, covered, padded, and resting easily on the hips. D is the point or fulcrum of support for all parts of the apparatus. This is certainly a philosophic affair, that appears well calculated to be worn a portion of the time, and for a time, in certain cases, until weak muscles can recover their counterbalancing capability.

The lower figure shows his *boot-splint*, as applied and worn on a paralyzed and contracted limb, which I have used with most satisfactory effects on children, while under electrical treatment for spasmo-paralysis, and for wasting palsy. F is a pawl and ratchet, to support the knee securely when walking, or to bend the limb while sitting. E is the thigh socket, wadded and adjusted to the size of the limb. C is the pawl ratchet and spring, to give easy support, and *incline* the foot to a natural position. It is certainly an admirable contrivance for the purpose. He prepares the same arrangements for palsied arms and hands, or contracted fingers. Mr. J. S. Drake's office and rooms for fitting these splints to palsied, withered, or contracted limbs, is at 297 Tremont Street, corner of Warren, Boston.

The advantages of division of tendons in older persons and longer standing cases, i. e., where there is structural shortening of muscles, and consequent limitation of movement and functions of articulations, with deformity, cannot be exaggerated. These are the cases in which the greatest permanent benefit accrues to the patient, and to the future reputation of the surgeon. When the previously contracted, *structurally shortened muscles* are divided by sub-cutaneous tenotomy, they evince *then* comparatively little tendency to re-contraction.

On the contrary, especially during childhood, when the contracted articulation can be moved through a considerable portion of the natural range of movement; when the resistance is somewhat elastic, instead of being rigid and unyielding; when in

the foot, for example, the patient, by throwing the weight of the body upon the member as in the act of lounging in fencing, can bring the knee over the point of the foot, (toes,) when the atrophy of the member does not amount to, or approach to, a loss of one fourth in its circumference,—then tenotomy is not required.

The means by which, in such cases, tenotomy is superseded, are those already recommended — diligent, painstaking manipulations, appropriate mechanical supports, and appropriate (muscular automatic) exercises.

The whole muscular system is so arranged and balanced that on any one part of the body, or of a limb, we find one set of muscles for a particular motion, and on the opposite side we find another set for the opposite motion. This is a *law* of muscular arrangement and motion: on one side of a limb are the flexors, and on the other the extensors; on the one side the pronators, and on the other the supinators; the adductors and abductors, and so on. The *power* of the respective antagonizing sets are by no means equal, although the *habitual function* of counterbalance for each other *is* very nearly equal. Now, if this functional equilibrium is disturbed, the counterpoise is lost, and the limb is drawn towards the stronger and *prevailingly* contracted muscles, and consequently the extended antagonisms are thrown quite out of their field of action. As a general rule, the *flexors* are stronger than the extensors, the pronators are stronger than the supinators, and the adductors are stronger than the abductors. For this reason, we are inclined to the modern view that the *gastrocnemii* and *soleus* muscles of the calf of the leg are the *flexors* of the foot; such, in fact, is the nomenclature adopted by Dr. Detmold, of New York, as also by MM. Rudolphi and Von Walther.

According to Dr. Detmold, the club-foot that results from *spasmodic* contraction is more difficult to cure than any other.

The club-foot after *paralysis* of the muscles is much easier cured, but it necessarily requires a long time.

The club-foot from *gradual* muscle contraction, if without spasm or paralysis, admits of the most favorable prognosis, such being far more readily cured.

In treating all proper cases of *contracted muscles*, from whatever cause, we find the *law* that electric currents run downward through the most palsied, atrophied, and contracted flexor muscles, for not more than a minute at a time, and then, allowing a recess of a few seconds, again applied running upward through the antagonizing muscles for a quarter minute, and thus reversed and alternated some half a dozen times at the sitting, as a general thing, has the best effects for dissolving all such curable contractions or *tonus* states of the muscle fibres, and gives the best results. This is proved, not only by the good result, but also, I think, from the opposite law, which is, that an up-running current, for one minute, that is then reversed on the antagonizing muscles for a quarter minute, (so as here to run downward for only a quarter minute,) and then up again for one minute, and so on reversed and alternated for some time, can ultimately work up a state of *tonic* spasm. The conclusion that we should fix in our mind is, that the downrunning current, that is maintained, say for a minute, running outward, from the brain and cord, towards the periphery and extremities, *affects the sentient nerves* of the part so acted upon more than the motory; and that the up-running current, that is, *running towards* the spinal cord and the brain, *affects the motor nerves* and muscles more profoundly than the sentient nerves, and that probably through *reflex* action.

Incomplete paralysis of the lower extremities, according to the views of Dr. Spencer Wells, is often connected with diseases of the urinary organs, and may not be dependent on spinal disease. If a patient comes to you with a tottering gait, complaining of weakness in the knees, and a tendency to stumble on any uneven ground, exhibiting a certain loss of that muscular *consciousness* which enables us to walk without watching the feet to know where to place them at every step, your first impression will be, very naturally, that you have to deal with a case of spinal disease. Your first impression may be correct. As you proceed with your examination of the case, you may find evidence of some kind of injury or disease about the spine, or possibly some proof that the disease is within the cranium.

But in another case you may find nothing of the kind, and you are driven to assume a diseased condition of the lower portion of the cord, perhaps a simple atrophy. Now, let me convince you that you can have all these symptoms, that they may go on to complete paraplegia, and the patient may die, and that then you may find the cord perfectly healthy, so far as our examination can teach us, while the *kidneys* and bladder, either or both, are found the seat of manifest disease.

M. Rayer, in his great work on diseases of the kidneys, (vol. iii. p. 168,) says, "The development of paralysis after diseases of the urinary passages is even now a fact unknown to a great many physicians." As the condition of the urinary organs improves, so the recovery of power in the limbs is manifest; but in fatal cases there will grow all the appearances of severe inflammation of these organs, while the brain, cord, and vertebræ are perfectly healthy. So that while, on the one hand, disease of the urinary organs is constantly caused by paraplegia, so, on the other, paraplegia, through the sympathetic, is frequently consecutive to diseases of the urinary organs.

To enable us to distinguish this form of paraplegia from that depending on spinal disease, Dr. Wells says, we must first bear in mind the history of the case, and compare this with the history of injury or disease of the vertebræ, or intervertebral cartilages, or inflammation of the cord and its membranes, and bear in mind the following characteristics: —

1. There is found in "urinary paralysis" some impediment to the discharge of urine, as one of the earliest symptoms.

2. This is closely connected with some obstinate gastric derangement.

3. The weakness in the limbs is rather extreme debility than true paralysis.

4. The tactile skin sensibility is but slightly, if at all, impaired, while the *muscular sense* may be, and usually is, almost totally lost.

5. The limbs are tolerably well nourished; they may be thin, but there is no marked muscular atrophy, and their temperature is very little lowered.

6. The sphincter ani is not paralyzed, though it may be weak.

7. The bladder preserves *some degree* of contractility.

8. There may be no pain in the back, and no pain on pressing the spinous processes or on applying a hot, wet sponge to them.

9. The degree of weakness in the legs is in ratio to the urinary disease; catheterism, and any removal of obstruction to free discharge of urine, is sometimes rapidly followed by amendment.

10. In the *early stages* of this form of *partial* paraplegia, there is no history of convulsions, or of cramps, spasms, formication, nor violent neuralgic pain.

Take a case still more advanced. The patient can yet walk a mile or two, perhaps, but the gait is tottering; the urine loaded with mucus, or muco-pus, and the phosphates; it soon becomes ammoniacal after it has been passed, and there is a frequent desire to pass it. Electro-magnetic or Galvanic currents, I feel quite confident, are of very great utility in such cases, but must be used *perseveringly*. You may send a pretty strong current, frequently *reversed*, through the weak muscles, on the dorsum of the ilium, on the loins, thighs, and legs, for a few minutes every day; or the patient may wear one of the little portable batteries, (Humboldt battery,) with the poles fixed alternately on either limb, so as to keep up a constant mild current for a few hours each day or night.

There are recorded many cases by M. Lallemand, in his work on involuntary seminal emissions, in which the patients were feeble, or vacillating in their limbs, and afterwards became subjects of incomplete paralysis of the lower extremities. I do not question, for a moment, that paraplegia is a very common result of *frequent* seminal emissions, whether voluntary or involuntary. Indeed, it is undeniable that the *frequent* agitation of the nervous system, particularly when so caused, does lead to chronic irritation, inflammation, and softening (or atrophy) of the spinal cord, with *paraplegia* as a necessary consequence.

Spinal Exhaustion. — I refer now to a form of paraplegia which comes on so insidiously that the sad victim of it, although young, or more likely along the very prime of life, is almost lost before he is aware that his health is seriously endangered. This disease is unaccompanied with pain, and it generally occurs in those gentlemen whose attention is so drawn from themselves, by active business or mental exertion, that they often pay no attention to the *earlier symptoms* — do not want to heed them, but rather strive to regard them as trivial and unimportant. Other cases of partial paraplegia, we know, are mostly inflammatory in their origin. The cases to which I now call attention are, I believe, *anæmic* from the first; they are, in fact and effect, cases of spinal exhaustion. You see the importance, then, of a correct diagnosis here, and as frank and open declaration of it to the patient.

The *history* of the person will assist you, if you start the right train of inquiry. Dr. Latham says, "*Prior* to diseases, to their diagnosis, their history, and their treatment, — prior to them, and back beyond them, — there lies a large field for medical observation. It is not enough to begin with the beginning of the symptoms. There are things and conditions earlier than the beginning of the malady, which deserve to be known. The *habits*, the necessities, the misfortunes, the very *vices* of men in society, contain materials for the inquiry, and for the systematic study of physicians, fuller, far fuller, of promise for the good of mankind than even pathology itself." The kind of inquiry here referred to and commended by Dr. Latham is, I believe, a part of, and an essential element of, true *scientific* pathology. With reference especially to diseases of the nervous system, its paramount importance is not — cannot be — too deeply impressed.

This class of nervous difficulty commences with slight numbness in one or both of the lower extremities. This is followed by some loss of power. There is no pain in the spinal region at all. When you examine the spine, you may thump or press upon the processes and about them, from the neck to the coccyx, without producing pain. Still in some cases there is marked tenderness over the *cauda equina*, below the second lumbar

vertebra. You find no evidence, says Dr. Lolly, in this connection, of "your patient having ever received any sort of injury to the spine. He cannot account for it at all. If, however, you ask him if he has had much sexual intercourse, he will say, *if he is frank*, *yes;* but more probably he will not acknowledge to it immediately, but when you tax him directly with not having been satisfied with the caresses and charms of one siren, but that two or more claim him for their own, and that his animal pride would not allow him to stint, he will generally acknowledge to the truth of the soft [hard ?] impeachment. If, on the other hand, he says, indignantly, that he never had connection with a woman in his life, and yet shows these symptoms and history, it is almost certain that he is the victim of that dread delusion, masturbation."

The first thing to be done in these most important cases, is to *stop the error of habit* — the exciting cause. But this, from a long experience in this special practice, is found to be the most difficult part of our task. *Rest*, bodily, mental, and erotical, is the most important point in all the treatment. If your patient will not submit to rest, entire rest, absolute rest from all venery, and that for a long time, you had better take your leave without prescribing at all. I have known mercantile men, who were of business habits and sound sense in all other matters, also men of the professions, whose judgment is of the greatest value to their parishioners, clients, or patients, but who were such slaves to their venereal appetite and their own ideas of pleasure, that they would submit to any, ever so severe, plan of treatment that you like to propose, yet would not much abstain from such pleasures, or give up or even relax their ordinary but too close and ruinous mental application, or inordinate exercise.

I remember once saying to a gentleman, who came on from Philadelphia for the purpose of putting himself under my care, but who had recently entered into a second marriage with a young, *vigorous*, and probably voluptuous wife, and as he was, and had long been, affected with precisely this state of "*exhausted spine*," not only showing this form of *partial* para-

plegia, but was also of late threatened with immediate *amaurosis*, — I say, I said to him, that if he did not desist from his prolonged or too frequent sexual intercourse, at least for a few months, and until his nervous system could rally and recover its vitality, he certainly would not be benefited, but, on the other hand, was liable to become more seriously paralytic, and a blind man ; and, therefore, it was only on these conditions that I would attempt to treat him. Such being my deepest convictions, he, the next day, after consulting with his wife, came into my office, stated his perplexity, and pleaded for easier terms. He finally concluded, however, to return home again, to give up all treatment, and "*go it blind.*"

We know also, that, on the other hand, it is a great fact, a very *physiological law*, that whenever muscles are but slightly used, or lie long inactive, they become soft, fatty, and weak, or else they *waste* or *degenerate ;* and this, whether the inactivity depends on paralysis, through affection of the nerves or nervous centres, or from simple inaction, or fixation of the parts they should animate and move. The degenerative process may be so rapid that, in a fortnight even, muscles paralyzed by some hemiplegia may present a manifest change of color.

Now, according to the views of Dr. James Paget, Professor of Anatomy, the course of events in these cases appears to be, that the want of exercise of the muscle, whether paralyzed or fixed, makes its due nutrition impossible ; and the atrophy thus brought about is the cause of the loss of irritability of the muscle — i. e., of the *loss of its capacity* for contracting. For the experiments of Dr. John Reid plainly show that loss of contractile power in a paralyzed muscle is due, directly, to its imperfect nutrition, and only indirectly to the loss of connection with the nervous centres. When he divided the nerves of the hind legs of a living frog, and then left one limb inactive, but gave the muscles of the other frequent and regular exercise by electrizing with the primary current the lower end of its nerve, he found (to state the case very briefly) that at the end of two months the exercised muscles retained their weight and texture and their capacity of contraction, while the inactive

ones (though their irritability, it might be said, had not been exhausted) had lost half their bulk, were degenerated in texture, and had lost some of their power of contracting. In other cases, too, he found the loss of proper texture always ensuing in the inactive state, before the power of contraction was lost. And it is doubtless the same in man. A muscle which, by no fault of its own, but through circumstances external to itself, has been prevented from acting, becomes shortly incapable of acting even when the external obstacles to action are removed. Hence, I think, we may deduce a rule which ought to be acted on in practice. When a person has had hemiplegia, one commonly sees that long after the brain has to all appearances recovered its power, or even through all the rest of life, the paralyzed limbs remain incapable of action — as motionless as at the first attack. Now, it is not likely that this abiding paralysis is invariably, nor even usually, the consequence of any continuing disease of the brain; rather we must ascribe it to the imperfect condition into which the muscles have fallen *during their inaction.* So long as the state of the brain makes voluntary action impossible, the muscles are suffering atrophy; then, when the brain recovers, they are not in a state to obey its impulse. They are degenerate; and thus, their inaction continuing, they degenerate more and more, and all remedy may become then impossible. If this be mostly true, Dr. Reid's experiments suggest a good part of the remedy. When muscles are paralyzed through affection of the nervous system, we ought to give them artificial exercise. They should often be put in action by electricity and otherwise, and that under repeated efforts of the guiding influence of the will. Their action, though thus artificial, will insure their nutrition; and then, when the nervous system also recovers, they may be in a condition ready to act with it. (See Appendix E, F, G.)

Wasting Palsy.

This affection has but a recent history in medical works, as the earliest well-defined cases are limited to the present century.

In 1795 was delineated to the medical world the first example known. But we are often led to query what could have been the nature of those cases of "withered hand" which received, at the hands of Christ, the compassionate cure by miracle? Says Sir Charles Bell, "This is an obscure subjeet." To this day, it is looked upon by physicians, that wasting palsy is owing to "defective nutrition;" but it is evidently more than this, for there is a rapidly progressive *diminution* of both bulk and power of the affected muscle, or muscle group. There is — there must be — some *mal*-nutrition, some perverted and devouring aetion.

Says Dr. Roberts, of London, cases of exeessive wasting palsy of the muscles of one or more limbs, *independent* of any well-defined *cause*, have, from time to time, been observed; and records of these are found scattered in various medical works. They have been, until recently, introduced as "*extraordinary*," or anomalous cases, and are referred to in systematie treatises as "creeping palsy," or as "lead palsy without lead," "peripheric paralysis," or "local palsy," or "progressive palsy."

This progressive wasting paralysis does not extend to neighboring parts of the leg or arm, nor is it a kind of blight that reaches so far up the limb, or so far down the limb, *but it is a morbid affection of muscles* acting under *a law of election*, that limits the progressive wasting to those muscles only *that are naturally combined in action*, although these muscles lie in different parts of the extremity, and are supplied by different nerves, as they are also supplied by different arteries. For example, the museles of the thumb may be affeeted by this disease, but the wasting and palsy will not be eonfined to the short muscles of the ball of the thumb, but will, rather, extend to those long museles of the thumb which lie upon the forearm; and these wasted muscles are seen lying side by side with those that are plump and powerful. In another case, all the extensor museles of a group, or of a limb, will waste away and lose their power while the flexors will preserve it; and this usually produees a eharaeteristie position of the limb. I am inelined to agree with the early views of Sir Charles Bell in attributing

these very partial freaks of disease to *visceral irritation*, and in that case it must be through the sympathetic nerves, just as we might expect. He evidently had distinct and well-defined ideas about these cases forty years ago. He correctly grouped them together, and yet, apart from all other kinds of local palsies, such as arise from injury of the spinal cord and nerve trunks, or from lead. In 1849, M. Duchenne, of Boulogne, presented a memoir to the Institute of France, entitled "*Atrophie musculaire avec transformation graisseuse.*" In 1853, M. Cruveilhier read *his researches* on this subject before the *Academie de Medecine*, and so graphic was the delineation of this mysterious malady, that progressive wasting palsy has been termed "Progressive Paralysis of Cruveilhier," or "Cruveilhier's Atrophy."

This is a truly formidable disease. What produces it immediately or remotely we cannot tell. It may occur without the least assignable cause in persons who have met with no accident, and are otherwise in perfect health. Wasting palsy may affect children and adults, male and female; but it is suspected to arise, sometimes, from protracted fatigue of certain muscles; also from bruising, and from cold. It is almost always of slow invasion, and is usually discovered first from the sensible loss of power; for by this, the attention of the patient or friends is drawn to the state of the muscles, when, perhaps, they are discovered to be already wasted, or soft and degenerated. There is also noticed, at times, a violent *quivering* in these muscles, which does not cause motion of the limb, nor any kind of pain. This *quivering* does not attend all cases of this malady, but when it does occur, it indicates that the disease is still advancing, and if it ceases, the disease is arrested, or the muscles are already totally destroyed. Some of these patients complain of vibrating cramps that prevent their sleep, but such are quite distinct from the tremblings. The muscle, or clan of muscles, is progressively destroyed, while the nerve branches, even down to the affected muscles, are at first apparently sound, and the general nervous system appears to be quite healthy. The attacked muscles appear, on dissection, of a pale yellow color, are wasted as to *number* of fibres, and their bulk is often

reduced to mere thin cords. Fat, which is always produced in degeneration, or retrogressive metamorphosis of tissues, become accumulated, in some of these cases, so as to fill up the place of the consumed or missing muscular fibres. In these cases there is not seen the remarkable wasting that is so apparent in others, for the limb may appear nearly, if not quite, as plump as before the attack. But where the sarcolemma, or sheath of muscle fibres, has actually been consumed in the morbid process, the sarcous elements become converted into fat and granular matter, and the last ramifications of the motor nerves there distributed become affected, and perhaps perverted, or were perverted at the onset of the malady. In some cases the fat is eliminated probably as fast as formed, and hence the extreme emaciation. It is supposed that this affection does, in some instances, extend along the motor nerves to their formation of the anterior root of the spinal nerves, and even atrophy of the spinal cord itself may finally be the consequence, but never the *cause*, of the primary affection. If this is so, did not this constitute the true "Tabes Dorsalis" of the more ancient medical writers?

Wasting palsy appears in two forms — the *partial* and the *general.* The partial form begins usually in some of the muscles of the hands or shoulders, with a tendency to spread to the body, and so threatening life. If it commences in the hand, it is usually in the right hand, and the muscles of the thumb are first affected. The belly of the thumb gives place to a great hollow space between the first and second *metacarpal* bones, and next, the *lumbricales* take on a state of tonus, or rigid contraction, drawing the fingers like claws, while the *interossei*, and also the *thenar* of the thumb and fingers, and the *hypothenar* eminences of the palm, are atrophied. Then from the hand the disease extends up the forearm. The extensor muscles of the fingers, situated on the outside of the forearm, are by far the most liable to be affected; but the flexors are, in some cases, likewise destroyed, or they alone may be affected. In this case the fingers are bent upon themselves, and so retained, much like claws, while they cannot bend upon the hand so as to grasp or hold

If the invasion of this terrible and insidious disease first affects the shoulder muscles, and by way of its usual preference, wastes, first, the *trapezius*, then the *serratus magnus*, the *rhomboide*, and those other muscles that hold the shoulder blade to the thorax, and in its natural place, then the outer angle of the *scapula* becomes depressed by the weight of the arm, while the lower angle is raised and projected widely from the body. The disease then spreads down the shoulder to the arm, wasting and palsying the *deltoid* and the *biceps*, which leave the shaft of the *humerus* near the surface, and the *acromion* and the *coracoid process* very prominent under the skin. The patient can no longer raise the arm, nor even feed or dress himself. It may then pass into the general form, sooner or later, and thus speedily cause death.

Then, again, if the invasion is of the *general* character, it will make its appearance in the muscles of the lower extremities, which will be first discovered from the fact that walking has rapidly become difficult, and as rapidly the muscles are found to have wasted away, and then the movements soon become quite impossible. The muscles of the thighs go first, and this wasting extends up to and through the spine, so that, next, the *pectoralis major* is found already consuming away. In this form, it is noticed, that all the voluntary muscles throughout the organism may be affected by it, excepting only the muscles of the eyeball and the muscles of mastication. But, when we see the ravages of this malady already wasting the *facial muscles*, then we know we have a certain sign that the disease, in that case, will shortly prove fatal. That is known by the whole physiognomy losing its expression; and sometimes the saliva drools from the lips. The speech is very slovenly and slow; swallowing difficult; the diaphragm loses tone, and respiration is feeble. The slightest impediment to respiration, now occurring, most generally closes the scene.

Wasting palsy is not a "self-limited" disease, in the common acceptation of that term, although in one peculiar sense it is so; but it is rather a chronic affection, and that in its profoundest signification. Its *tendency* is to death, although in some

rare instances it is arrested, so that recovery and years of health may follow. It is scarcely necessary to say, that in such a disease, the more recent cases — i. e., after a lull in its progress — are the most hopeful for recovery. Consequently the more recent and partial cases are to be taken for hopeful treatment, rather than those of long standing. The currents of Galvanism or Faradaism, are the only, or certainly the most powerful, means known for arresting the progress of this affection, and turning the tide of adverse bodily action into a healthy direction. That certain cases, and particularly such as are of the general kind, do run their fatal course in spite of electro-therapeutics and all other treatment, is, as Dr. Althaus says, no disparagement to electric remedies, for they cannot be expected to accomplish every thing, — even impossibilities.

The indication in the electric treatment is much the same as that in lead palsy; i. e., to cause the muscles to contract as separately, as strongly, and repeatedly as possible, and yet without too much fatigue; to cause the dilatation of the capillaries at one moment, and the contraction of the blood vessels at another; and thus attract to, and urge more blood through those tissues, to warm and nourish them; and finally that by the chemical, or rather the *catalytical, action* of Galvanism or Faradaism, the mal-process of animal chemistry may thus be so broken up and disturbed from time to time, and under such circumstances, that the ever-ready laws of vitality may arrange and re-arrange, and restore those processes again that we term natural and healthy. To bring about so desirable a result, *we must persevere for a long time*, even where no tangible improvement is produced, say for the first month or so; but so soon as it is found that we *thus arrest the further progress of the malady*, we shall be all the more likely then to improve further the condition of the patient, and very possibly to effect a cure.

Dr. Budge, in an interesting paper communicated to the French Academy in 1858, stated that he had ascertained that the actual number of muscle fibres increases with every year during the period of growth; so that the increase of muscular

tissue does not depend alone upon enlargement of the individual fibres of the muscles. He has also discovered that starvation diminishes the *number* of the fibres, and also notably lessens their individual size. This answers the old query whether during growth, and the hypertrophy caused by healthy exercise, the muscular fibres of animal life increase in *number*, or merely in *size*.

M. Becquerel and M. Valerius are of the opinion that true and *still active* wasting palsy are not proper cases for the trial of electro-therapeutics. M. Duchenne, however, says that as long as the muscles show the least signs of electric response, even if only by the smallest fibril wave or contraction, and up to the period when fatty transformation is about to set in, he hopes for, and attempts by the aid of electricity the restoration; and it does seem to me, that here he has succeeded wonderfully, not only for amelioration, but for actual cure. But I find this end is easier attained where the atrophy is local, and where it is the effect of too close application, or rather from a work of unremitting *sameness*, that has overworked and exhausted a certain class or classes of muscles. When the case is spontaneous and general, and that without special cause, then I reckon there is far less hope, if any at all. We may, moreover, have presented to us for treatment a local palsy, attended with atrophy, first, from inaction, or, second, from over-action. The former requires gentle and often-repeated exercise, with electric treatments; while the latter requires rest, automatic movements, and champooing, and this aided with electric treatments, to cure. These can usually be successfully treated, but are apt to remain feeble, and if overworked again they are very liable to relapse; hence the actual necessity of cautioning the patient or his friends.

Dr. Duchenne, who certainly has had very great experience with this class of cases, is disposed to believe that a new formation of conduction, or *capability of conduction*, here takes place in the nerves, much the same as is known to occur under favorable circumstances, through a cicatrix, so as to restore one way sentient nerve influence, and the other way motor nerve influ-

ence, and that with muscle contractions; thus not only arresting the progress of the disease, but even re-making or multiplying the individual muscle fibres. But this can only be hoped for when the cause of the disease ceases to act. He thinks that the electro-magnetic currents are, on the whole, best; that great *battery* power is required, and that with a very rapid vibration. The greatest obstacle to this method is, to persuade the patient to bear it; but as the sensibility increases, so must the intensity of the current be diminished. A sufficiently strong Galvanic (primary) current is very much more bearable than the Faradaic currents of the same strength — i. e., that can produce the same muscular contractions. For this and other important considerations, I prefer, for these cases, the former.

The "*essential paralysis of infancy*," affecting more frequently the lower limbs, may as well be classed with those of *wasting palsy*, for they, too, are characterized by a gradual wasting and a progressive paralysis; but the former cases appear to proceed rather from an affection of the anterior nerve roots, as they leave the spinal cord, and require our particular attention. May not this, in fact, yet be found to be the true pathological condition of the *general* form of wasting palsy? But Dr. Duchenne has treated many such infantile cases, and concludes that localized Faradaic currents applied along the *sides* of the spine, and over the affected muscles, may abridge the duration of the paralysis, and diminish, if not prevent, the attending extreme atrophy of the muscles, and, moreover, prevent their fatty degeneration. Some of these run a rapid course to a hopeless state, and that, sometimes, in only a very few months. But more generally, within the year after the attack, there is hope; while, in any of the worst cases, we find that there is no evil from a reasonable use of electro-therapeutics. It is well therefore to try this treatment thoroughly, even where there is at first no electro-muscular response, as there may be a possible chance of success; for I have certainly found an occasional case that gave marked improvement, after years' existence of the malady; but of course the *progressive* character had then been arrested, and the case had long remained simply *in statu quo*.

Hysterical Paralysis.

A true hysterical paralysis is seldom seen without other marked symptoms of hysteria, either present or past, as globus, cramps, pains, or some uterine disturbance; but in other respects, this paralysis *very nearly resembles* those cases that are caused by disease of the brain or spinal cord, or those of rheumatic palsy. This affection is more usually found to involve the muscles of the arm and leg on the same side; if both, then it is termed *hysterical hemiplegia.* If it be seated in the *recti* muscles of the thighs, or other muscles of the legs, (for it is more likely to attack but one limb,) then it is called *hysterical paraplegia.* If it be local, and affecting only a single muscle or muscle group, then it is termed *local hysterical palsy.* If it be local in a joint, then it is termed an *hysterical joint.* But in *this kind* of paralysis there is no sort of disease of the motor nerves, nor yet of the nervous centres. It may gradually appear, or it may attack suddenly, as from fright, great excitement, intense anxiety, or profound grief.

According to Dr. Duchenne, we should find the test of electro-muscular contractility in all cases of hysterical palsy, at the normal state, i. e., as in health; but that the "*muscular consciousness*" is nearly or entirely gone. Now, this is not found to be true in the great majority of cases of some standing, who apply for treatments, while *it is quite true of some of the more recent cases.* The greater number of cases who call for aid are of long standing, and these, certainly, show a marked diminution of susceptibility to the electro-muscular contractions. And another thing I can say, speaking from experience, and that is, that nearly every case of hysterical paralysis, no matter how bad or how old the case, can be cured by well-directed electro-therapeutics, aided by any other needed rational medication and regimen.

I know it is true that some cases of "hysterical palsy" and "hysterical joints" are little more than mere *fantasy*, and are kept up in a great measure, as Dr. Rowland says, "by the

patient lending herself to the task, and refusing to exercise her command over the refractory muscles or joint." A rough *shock*, or *a strong moral impression*, or rather "*occupation that continually interests*," may at once remove the disorder in some such cases; but it is exceedingly doubtful in my mind whether any such means could be productive of benefit, in many other cases. Hysterical paraplegia may *commence* from irritation of the uterine nerves. There is a form of this affection that is always accompanied by some kind of derangement in the function of the womb, or bowels, or both, and is as totally unallied with organic change, or any action conducting towards such change, either in the brain or spinal marrow. The attending "pain in the back" is that commonly known as *spinal irritation*. It varies from day to day, sometimes being very severe, at others almost null, while perhaps slight pinching up of the integuments that cover the spine is as productive of actual pain and suffering as firm pressure could produce. The lower extremities are rather colder than natural, and *there is an entire absence of ordinary* sensation in them; and when the limb or limbs are strongly flexed, there is severe pain. There is pain also from slight pressure in the lower dorsal region, or over the sacrum. The appetite is wrong; the bowels are slow; the sleep is wanting, or is disturbed; and the urine, upon test, is found loaded with lithates. Such it is.

Case.—Mrs. C., of Brookline, twenty-seven years of age, had been troubled with a partial paralysis of the right lower limb for some five years. Sometimes it would be better, and then again there would be months together when the limb would be so paralyzed that she could scarcely get about the house. She had been long under the treatment of one of our oldest and best physicians, who also believed her to have been an exquisitely hysterical girl. Since her marriage she made the tour of Europe, spending a season in Italy and Switzerland, where she became quite well. She could climb mountains, the long stairways of palaces and towers, and even the pyramids. But she was no more than home again, than she was as lame (i. e., as paralyzed) as at her worst. This condition was not now intermit-

ting, or in any sense remitting, for her limb remained in this state during the summer and fall, until she came to me for electrical treatment. She could scarcely walk when assisted; but there was one very noticeable feature, for while her walking was slow, hesitating, and extremely irregular, there was a dragging of the palsied limb after her, as if a piece of inanimate matter. This indeed is pointed out by Dr. Todd as the very *diagnostic sign* between hysterical paralysis and all other lower-limb paralyses arising from other causes. In fact, the limb appears to be merely drawn straight along by such a patient, just as if inanimate, or as an artificial limb, while the foot swings to the one side, nor is she able to straighten it.

Upon applying the electro-magnetic *test*, I found that the *rectus* of the thigh did not at first respond in the least to the half-strength current; but if the electrodes were then similarly placed upon the sound other limb, response was there prompt and complete. Thus was this by history and test, fairly diagnosticated as a case of hysterical paralysis, and as such was treated by suddenly *alternated* primary and secondary currents of electricity. The electrodes were always placed, the one over the nerve trunk, say at the right abdominal ring, or at the anterior crest of the ilium, or just under Poupart's ligament, while the other electrode was being swept along the border points of the affected muscles, and at the same time using a strong Faradaic current that was suddenly reversed, say every fifteen seconds, by the current changer of the key-board. The sittings continued never over fifteen minutes, and were repeated every other day for one month. The cure was complete.

Hysterical paralysis of the bladder is not uncommon, and it should be recognized, so as to receive the general and constitutional treatment and regimen, as clearly and as thoroughly as the local. Sir Benjamin Brodie indeed lays down the *rule*, that the catheter should not be resorted to in these cases, *only in those extreme exceptions* where the paralysis is actual. A similar want of power over the *rectum* sometimes occurs in this *state* of the nervous system. Now, in most of these cases, it is not so much the fact that the muscles are incapable of obeying the orders of

volition, but rather that *the function of "volition" is suspended.* Therefore, if electric currents are applied to the spine to re-establish this function, it affords the cure. (See App. E, F.)

Hysterical Affections of Joints. — Sir Benjamin Brodie states the remarkable fact, which no one is so well able correctly to ascertain as a surgeon of his great experience, that four fifths of the supposed cases of *joint diseases* which occur among the better classes are truly hysterical. You may always expect to find in these cases other indications of the hysterical state. See his practical little volume on "Local Nervous Affections." He says there is always exceeding tenderness. The joints most frequently affected are the hip and the knee. The patient keeps the painful joint quite at rest, and always yielding to a partial flexed position, and being fearful of the least disturbance. When the joint is moved by you, she will call out with much more expression of pain than if there were actual ulcerative disease of the cartilages.

Dr. Balman, of Liverpool, gives an interesting account of a case of *hysterical paralysis* in a young lady of seventeen, that had been treated for three years for curvature of the spine. The curvature at first appeared to be lateral, but subsequently angular curvature came on. When he first saw her, she was upon the sofa, looking pale, but otherwise appearing well. Her attendant said she had been unable to stand, walk, or speak, since the fit of the previous day. "Upon examination," he says, "I found the spine very crooked, with an angular curvature of the last two dorsal vertebræ; on passing my fingers down the median line, there appeared to be distinct tenderness both between the scapulæ and over and about the seat of the projecting spine, extending down to the sacrum; the feet and limbs were cold, livid, and completely insensible to the prick of a needle, as far as the knees; the hands were in a similar condition, but the loss of sensation did not extend beyond the wrists.

"Although unable to stand or support the body for a moment without assistance, I soon afterwards learned she was enabled to turn the feet about in almost any direction when lying down in bed; her nights were restless and without sleep, and the eyes

presented that peculiar glistening aspect so characteristic of hysteria. She complained of headache, and cramps over the whole body; these were rendered very distressing by cold, and pressure of every kind; even a very powerful liniment served but to renew the cramps, and destroy all sense of feeling on being applied to any part of the body. I very soon had an opportunity of seeing her in one of the paroxysms, which now generally occurred about once in twenty-four hours; these, as in similar cases of this mysterious disease, were truly frightful to witness; the limbs were extended and rigid as marble; hands clinched and immovable; the head and neck thrown back; whilst the whole body appeared to be convulsed and writhing under the most violent tetanic spasms. Sometimes the symptoms for a time assumed a different character, and she would lie motionless in one position for hours together, in a state more resembling catalepsy than any thing else.

"I commenced the treatment with the usual routine of antispasmodic and tonic medicines, such as ammonia, iron, fetid gums, &c., without much apparent benefit; opium was administered at night, to soothe the irritability of the nervous system and induce sleep, but without success; three grains of solid opium, given at bed time, served only to make her still more restless, without any narcotic effect being produced whatever.

"September 6.—After one month's trial of these, and a variety of other remedies, finding matters but little improved, the pain in the lower part of the back being constant, and the severity of which I was inclined to think contributed in a great measure to renew the fits, whilst the paralysis, if it may be so called, remained stationary, I began to think that there must be some irritation of the spinal cord or its membranes. I now, therefore, applied seven or eight cupping glasses along the whole of the spine, *every alternate day;* prescribed small doses of the hyd. c. creta and carb. of soda every night, and a turpentine enema every third morning. On one occasion I ventured to apply the scarificator, and took about three ounces of blood, with evident relief. Under this mode of treatment she began steadily to improve; headache much relieved, and the pain and tenderness

of the back not so urgent; she also soon passed better nights, sleeping three or four hours together soundly; the attacks returned on two or three occasions afterwards, always just before the approach of the catamenia. The lower extremities, however, continued useless, and without any return of sensibility, and she had, as usual, to be carried by her attendant from room to room. I now commenced to apply galvanism, with a view of restoring the use of her limbs. At first the shock of a very powerful battery was not felt on placing one pole to the sacrum and the opposite one to any part of the leg below the knee; but after a few trials I found one isolated spot, about the circumference of a shilling, over the outer part of the tibia, a few inches below the knee, sensitive to its effects. Continuing its use every day, the feeling seemed to radiate day by day downward, over the whole of the external part of the leg to the ankle, the inner part of the leg remaining, as before, completely unaffected by the electric current; the sensibility, however, soon returned here likewise, and extended gradually to the extremity of the second toe. Immediately after the next *seance*, I learned with satisfaction, that soon after my leaving the room, my patient got up very coolly and walked across the room, and indeed over the whole house, unattended or supported by any one. This happened on the 12th October, since which she has continued to take regular walks out of doors for considerable distances, and is rapidly improving in all other respects."

As regards the actual seat of this disease, it in all probability was connected with some congested state of the *spinal veins;* and, indeed, it does not seem very difficult to imagine why this state of things should occur, if we carefully examine the anatomical arrangement and structure of the venous system of the spinal cord. Thus, according to Breschet, there is every thing here calculated to favor stagnation of the blood.

1. The veins are deprived of valves, thinner, and much more delicate than in any other part of the body.

2. They are relatively very numerous, subdivided, and tortuous; so that each spinal nerve may be said to be literally encircled and bathed in venous blood, as they penetrate in the intervertebral foramina.

The consequence of this arrangement, notwithstanding the frequent communications by which this impediment is in some degree obviated, must be, that the blood will move more slowly, and with greater difficulty. That congestion does sometimes happen from this peculiar disposition of the veins of the spinal axis, must, therefore, be extremely probable. Olivier mentions that he had often found in his dissections fibrinous clots blocking up and distending the veins of the spinal cord, and even those which accompany its nerves; and many other instances are related by Morgagni.

The influence of electro-magnetism in restoring the power of locomotion is here certainly more remarkable than any thing ordinarily witnessed. That this was in reality the result of the electric stimulus, and not, as we know is sometimes the case, by some sudden moral impression unloosing the magic web, which seems to hold captive the power of volition, I think there cannot be the least doubt. The effect of this agent was perceptible at each application; for it was not until the remedy had been persevered in for some time, that the beneficial results were manifested so strikingly.

"To show how powerful electricity can stimulate the voluntary muscles," says Dr. B., "I may add that she felt, as she often expressed, a strong inclination to walk after each *seance*,—so much so that she many times made the attempt, but always without success,—falling thump upon the floor, until the period mentioned; and even then, when she had regained the power of standing in the erect attitude, it required much determination to keep it; and but for the exercise of a series of movements, she feels convinced that she would not have been able to retain her position.

"I may mention that I have made trial of this remedy at a much earlier period in this case without observing any benefit; on the contrary, many of the symptoms appeared to be aggravated, after its use. It was, therefore, at a particular stage of the disease, when counter-irritant and alterative medicines had removed the more active symptoms of the complaint, that galvanism appeared to do good. This remedy, therefore, like any

other, is applicable *only under certain conditions;* and the success of it will depend not only upon the tact and acumen of the practitioner in the selection of his cases, but also the particular phase of the disease at which its use is apparently indicated."

There is a singular case mentioned of a young girl aged seventeen years, that must be rare, but it is quoted here to show the rallying power of electricity in some desperate cases. This case, by the way, was witnessed by MM. Coindet and Duval, in Geneva. It seems that, under an hysterical influence, there suddenly appeared on the hand of the young lady a "gangrene," the result of a temporary stoppage of the circulation in that limb. All the fingers of her right hand became of slaty color, cold, and anæsthetic, and the patient suffered at the same time most acute pains; the radial pulse was totally gone. Here — i. e., in this stage, after all other means failed — electricity, after Dr. Duchenne's method, was hastily adopted, and after only ten minutes, the girl cried out that she was able to move her fingers, and she did move them; the pains, that had been agonizing, ceased; the radial pulse reappeared; sleep, which had been wanting for five nights, was at once enjoyed; but upon waking, the pains returned. After each *seance* the pains were calmed, stiffness of the fingers was less firm, the night's rest became good; the rigidity of the arm soon disappeared after the first *seance*, and the throbbing of the arteries was established as natural. What was very remarkable, from the second day, there was produced, after each treatment, a profuse transpiration from the fingers of a very fetid odor. In seven days, the color and warmth of the hands were mostly restored, although her general health was evidently broken and poor. We see, however, that the local good effects of the currents were incontestably evident. (See pp. 412, 477 Note C, and App. F, G.)

Aphonia, or Loss of Voice.

Dr. Grapengeesser, a German physician, cured a case of aphonia by means of voltaic electricity, as long ago as 1801. He drew a blister on each side of the throat, as had been recom-

mended by Baron Humboldt. After removing the raised cuticle, he applied to one of these sores a small plate of silver, and to the other a small plate of zinc. These two plates, being first bound on the sides of the larynx of the patient, were then brought into metallic contact by means of the two connecting wires, which were brought together and twisted. This was borne but for a quarter of an hour. The larynx began to heave convulsively, and there appeared also an abundant flow of ichorous fluid from the raw surfaces, and a sighing or sobbing continued for some time. There was soon observed a free expectoration of mucus, which was followed, in the course of two hours, with some little voice. This primitive "*localized*" galvanizing was thus repeated from day to day for a few more times, and which was attended with like phenomena, when the voice and power of the throat were perfectly restored. The loss of voice in this case, I should have said, was of several years' standing.

In the Dublin Quarterly Journal for February, 1847, is recorded a case much the same, and which was treated in the same manner, and with the same good result. But in this instance, the improvement in the voice began in the evening of the very first day, after the first application of the metal plates to the blistering on the sides of the throat. The case continued to improve until the fourth day, when the voice was again lost. But the process being repeated, and this time, moreover, the apparatus being allowed to remain on all night, this was followed with the other effects in permanently restoring the voice, which continues.

Dr. Duchenne gives an account of two cases of hysterical aphonia, one of six months' standing, and the other of more than two years, both of which he treated and cured by the direct Faradaic use of electro-magnetism, *directed to the larynx*. He also makes mention of other cases of cures, but he mentions no failures.

Dr. Althaus, of London, appears to have had ample facilities for trying electro-magnetism in *hysterical aphonia*. Of the fifteen cases he saw, two were married, thirteen were single, and

the most of them were under thirty years of age. In no cases, he says, were the signs of such a morbid state, either of inflammation or of ulceration of the larynx, as would have accounted for the loss of voice. But the affection consisted merely in the loss of power in the nerves and muscles of the larynx. One case, he says, was suffering from a venereal disease, and the merely paralytic character of the complaint might possibly have been overlooked. There was a syphilitic eruption over the skin, and a large node over the right eyebrow, so that by a superficial examination one might have been led to the diagnosis of aphonia, resulting from syphilitic ulceration of the larynx, but the signs of such ulceration were not present. A few applications of electricity proved beneficial. In some other of these cases, there was a thickening of the mucous membrane of the larynx; others had taken a cold just before; others did not know of any cause, but on awaking in the morning, found the power of voice gone. The voice was totally lost in all these cases, but some of the patients were able to whisper by movements of the lips and tongue. All complained of a sore feeling in the throat; four of them felt pain in or about the chest, and in the epigastrium; three were irregular as to the time of entrance of the catamenia, but amenorrhœa was not present in any one of them. In two cases, aphonia was only one of the symptoms of a deep hysterical disturbance of the whole nervous system, for these patients suffered from globus, headache, cramps, &c. Dr. Althaus says, in order to give electro-therapeutics a fair trial in all these cases, he employed no other sort of medication. He used mild induction currents, mostly directed to the crico-thyroid muscles, and also to the recurrent nerves. This proved beneficial, for out of the fifteen cases, eleven were cured in a very short time. Faradaization proved unsuccessful in four cases, which had been of long standing. But in the eleven uncomplicated, which had not over four months' standing in any of them, he obtained the following results: One case was cured by one application of electro-magnetism, the voice returning in about three or four hours after the *seance*. Two cases were cured by three, and the other

eight cases by four applications each. In six cases, when the voice did return, it was at once, and as strong as it had ever been. In five of these patients, there was an evident increase in the sonorousness of the voice, which was discernible from the beginning to the end of the treatment.

A severe and long standing case of aphonia in a man, cured by means of galvanism, is thus reported in the London Lancet: "Theodore M., 24 years of age, of sanguine temperament and robust constitution, had enjoyed good health until an affray, which was followed by a violent fit of epilepsy, and the sequel of this was entire loss of voice. To restore this, local and general bleedings and antiphlogistic measures of all kinds were employed without effect. The tongue was now enlarged, reddened, and dry, and the blood vessels around its base were much distended. Taste was still perfect, but the movements of the tongue and of the larynx were performed with the greatest difficulty. Leeches to the sides of the tongue, and other active remedies, as tartar-emetic plaster, was placed over the larynx; but all these means failed to restore a healthy action in the parts adjacent. Sixteen months after the attack, the primary current of a battery of 50 pairs was employed, by placing the positive electrode over the cervical vertebræ, while the negative was upon the parts affected. On the first day, 200 shocks were thus given; and on the second day, 300 shocks; but no perceptible good or bad effects followed. Two days were allowed to elapse, and then a battery of 70 pairs of plates was used," (the kind of battery not given,) "so that some 300 shocks were at this time given. The patient was now found acutely sensitive to the action of electricity, and a lapse of five days was permitted to intervene before its fourth application, which then consisted of 400 shocks, performed with the same battery."! The reporter of this case says, "Whether these shocks had been administered too precipitately, or whether his system had become more susceptible to galvanism, the patient, after this last application, became much more agitated, and subsequently fainted for a short time. Next day he suffered intense headache, his face was flushed, eyes lustrous, pulse full and strong, from which state he was relieved by copious bleed-

ing. But he now, for the first time, gave utterance to hoarse sounds. After a delay of six days the battery of 50 pairs was again employed, and 300 shocks more were given. The same treatment was repeated every two or three days, and then, at similar intervals, 400 shocks were given with the 70 pair battery. The voice, meanwhile, and the motive power of the tongue and larynx, gradually returned to their normal condition; and after the twelfth such seance, the patient was completely restored. The deduction drawn from this, by the surgeon who has reported the case, is, that no nervous affection whatever should ever be regarded as incurable, until electricity, in some form or method, has been fairly tried and found to fail."

I have quoted the foregoing case, not as an example of treatment, by any means, but to show an heroic procedure, that should rather be avoided than imitated. Supposing the galvanic battery to have been the most mild, i. e., constant, — as, for example, the improved Daniell's battery, and only twenty-five cups were used,—if directed by a *small* electrode to the trunk of the affected nerves, with some dozen interruptions for three minutes at each seance, I believe the same good result would have followed, without the least hazard. And probably it would be better still to employ electro-magnetism first, by means of small electrodes directed *stabile*, to the trunk and branches of the nerve affected, and then finishing the seance by employing larger sponge electrodes *labile*, both over the throat, cervical plexus and region, as well as over the throat and down the sternum.

Professor Sedillot, of Strasburg, lately brought a case of complete dumbness and aphonia (" deaf and dumb") of twelve years' standing, which he rapidly cured by means of electricity, before the Academy of Sciences of Paris.* The details run thus: " The patient, a woman 30 years of age, had been visited 12 years before admission, (Nov. 19, 1855,) with complete dumbness and aphonia, in consequence of a fright. Various modes of treatment had been tried without success. The patient understood every thing said around her, and answered by gestures, but could utter neither word nor sound. The tongue was retracted

* Braithewaite's Retrospect, No. 34, p. 30.

and directed upwards, the woman not being able to bring the apex of the tongue in contact with the teeth. Deglutition and general health good.

"Professor Sedillot suspected here a paralysis of the muscles connected with the *cordæ vocales.* Inductive electricity was therefore prescribed. One pole was placed alternately on different parts of the tongue, while the other electrode was on the mastoid process, or under the lower jaw, or on the superior and posterior region of the neck, or on some part of the face. Some pain was thus experienced, but the tongue moved more freely. The first sitting lasted merely a few minutes, and was not repeated until one week after, owing to a severe headache which had followed the application. After the second sitting, the tongue could be protruded between the lips, and the patient began to talk distinctly, though the voice had not, as yet, quite returned. Pain was experienced in the region of the styloid process and the hyoid bone, when efforts at articulation were made, depending, very probably, on the *fatigue* of the muscles which had but just recovered their tone. The improvement became more and more manifest by a few more sittings; and a fortnight after the last *seance*, the patient returned home, perfectly restored. Several cases of recovery of speech by the means of electricity have been recorded, but none in which the affection was of such long standing, and then so rapidly cured."

The author could add here quite a list of cases of nervous or atonic "loss of voice," both in the hysterical and others, that have been successfully treated and cured by the application of electro-magnetic currents to the throat, tongue, and parts affected. Cold air blowing directly upon the uncovered neck appears to have been the cause of this affection in some of these cases, while various debilitating causes produced the affection in others. Over-singing, or going immediately into the cold after speaking or singing, bad dentistry, or *slight* chronic bronchitis appears to have preceded one and another troublesome case. Dr. H. I. Bowditch sent to me the past winter a patient with complete *aphonia* for electrical treatment — a Mrs. K., twenty-

eight years of age, who had overtaxed her voice at a social gathering. This lady was a mother of three children, and herself appearing to be, otherwise, in excellent health; but her voice was totally gone, and had been so for months, in spite of medical treatment and patient waiting.

The *treatment* for the foregoing case was performed exclusively with the electro-magnetic current. The *seance* was usually commenced by using large moist sponge electrodes, and placing the positive on the back or side of the neck, while with the negative one *labile*, i. e., as it were, bathing the throat, the upper sternal region, and the upper portions of the pectoral muscles with this brisk current of electricity for about one minute, to work up a degree of susceptibility; then these were replaced by very small and covered metal electrodes, or small sponge-tipped ivory electrodes, which were planted, the one on the middle posterior border of the *sterno cleido mastoideus* muscle, while the other was swept along over the front of the throat, producing as strong throat muscle contractions as possible, first by a down-running current, then by an up-running one, but occupying certainly the most of the time of each sitting, (which was some five or six minutes in all,) with the current running downward, or direct. This was reversed from time to time — say five or six times during as many minutes. It was repeated daily, and then every other day, for a fortnight, when there was a marked improvement. From this time the voice returned gradually, so that in two months she could sing with the same sweetness and power as ever. The *gradual* restoration led me to reckon this as more a case of local muscular atony, than a pure "nervous" affection; for the hysterical cases, so far as my observations go, recover *instanter* when they do at all. The *Humboldt battery* is capable, of itself, to work a cure in the nervous cases, if simply worn a part of the time. (See pp. 337, 477, and Appendix.)

Dr. Charles A. Lee, of New York, testifies decidedly in favor of the more frequent resort to electro-magnetism in the various partial palsies that occur, as the sequels of various diseases. He says, "I have certainly derived signal benefit in very many

cases of local palsy, from the employment of electricity applied to the paralyzed muscles in currents of moderate intensity, gradually increased in force during the *seance;* and although there are cases that will not be so benefited by it, yet there are others which will yield most readily to the judicious and repeated applications of this remedy." *

Finally, I lay it down as a *rule*, that, in all such cases as admit of the external and internal use of *stimuli* or *tonics*, as in the asthenic and more chronic cases, such are also proper cases to receive prudent trials in electro-therapeutics; and currents of moderate electro-magnetism are my *first choice*, usually, for this purpose. If this is received favorably, (i. e., for the better,) or even negatively, (i. e., harmlessly,) say for two or three *seances*, then I conclude that still more good may be developed by the *disturbing*, chemical action, or from the direct *catalytical* in-working of galvanic currents, or even from stronger currents of induction, or from static shock, or sparks drawn from the throat muscles.

CHAPTER VIII.

SPASTIC DISEASES.—CRAMPS, SPASMS, CONVULSIONS.

Dr. Marshall Hall maintained that the spinal system is the *source and seat* of all the classes of *convulsive* diseases. There are, he says, several important physiological facts to be noted, (and here we condense his statements,) viz.:—

1. If we puncture, or lacerate, or otherwise injure the cerebrum or cerebellum, or the cerebral nerves of special sense, in every possible manner, we observe *no results*—*no phenomena*, no expression of pain, no excited movement. The cerebral system, in all its parts, is, *in this respect*, inexcitable.

2. If we touch any part of the spinal system, and especially the spinal centre, with the mere point of a needle, if ever so slightly, then there are immediately excited muscular move-

* See a French work "*Diptheritic Paralysis,*" by M. Manigault.

ments, spasms, or convulsions. The spinal system is, in all its parts, *excitor — excito-motor.* These important facts constitute, according to him, the foundation of all our knowledge of the diseases of the nervous system, and are the very *source* of all *diagnosis* in regard to them. These facts hold good in regard to the living human body. By experiment and by observation, then, we are led to these conclusions: —

3. No lesion of the cerebral system, *if limited to the cerebrum*, can be attended by spasm or convulsion.

4. No structural lesion of the spinal system, short of absolute destruction, can possibly occur without exciting *spasm* or *convulsion.* If the destruction is complete, then there is palsy.

If, in affections of the cerebral system, we observe spasm or convulsion, it is because it is *not limited*, in itself or in its effects, to the cerebral system. Thus congestion of the centre of the cerebral system may, as in hanging, become extended to that of the spinal system, and then spasm or convulsion appears.

Again, affections of the spinal centre may consist of mere light or gently-applied *pressure*, not in absolute lesion of tissue; and then paralysis, not spasm or convulsion, will be observed. Or it may consist in sudden or violent *shock*, or in utter destruction; and then, I need scarcely say, paralysis, and not spasm or convulsion, will occur. All this we have seen demonstrated by experiment; all this you will see again and again in your observation in clinical practice, and especially in the surgical wards. What a means of *diagnosis*, then, have we obtained by these simple physiological facts! How has physiology become our guide in practice! I have thus explained to you how disease of the cerebral centre may, *by pressure downward*, affect the spinal centre. But another question arises — How does a disease of the spinal system, as a pure convulsive malady, affect the cerebral? — for such is a frequent event, as we observe in epilepsy.

"Notice what occurs in the most *marked* cases of this dire malady. The head becomes fixed, or there is *torticollis*, *by the action of the muscles of the neck* — a trachelismus; the jugular and other veins of the neck are compressed; the capillaries

of the neck, the face, and of the intracranial structures are congested; the veins swell, the arteries throb; the *cerebral centre now* becomes implicated. *All is intelligible; all is explained!*

"Affections, then, of the centre of the cerebral system are extended to that of the spinal system — to the *medulla oblongata* by the *downward pressure;* while affections of the spinal system are extended back again to the cerebrum *by trachelismus!* That *all* this is so is demonstrable. That it is *always* so, is, perhaps, what I ought not to assert. And does it not constitute a beautiful specimen of the *physiology of disease?* Such is the whole of our recent views of *epilepsy*, and of the *class* of convulsive diseases as observed in the clinical wards.

"Observe, now, with me, an experiment or two. I have removed the cerebral centre of this frog. Its spinal system is still most lively and energetic. I take and rub the toe between my thumb and finger; you observe the almost convulsive movements produced; I now touch the upper part of the spinal centre with this needle, and you see the animal is thrown into the most violent convulsions! Now, these experiments are *types* of disease; they are the types of epilepsy and other convulsive diseases. The first experiment is the type of *eccentric* epilepsy. The second experiment is the *type* of *centric* epilepsy. The first was induced by an excitant applied to a part of the spinal system at a distance from its centre; the second, to that centre itself. So is it in epilepsy. So is it in convulsive diseases generally in the human family. Do not these simple and illustrative facts interest you? They are of the deepest interest. Do you not now perceive *how* dentition, and gastric, and enteric, and uterine irritation may excite spasms or convulsions, or even epilepsy?

"You see, again, the violent convulsions which I excite by touching the spinal centre of this frog by this needle. Such is the dire state of things in centric epilepsy, whether this be of organic *origin*, or have been organic in its *course;* whether it be congenital on the one hand, or inveterate on the other. The cases of epilepsy which occur in private practice are, for the

most part, of the former or eccentric kind, and are *curable;* however, for many reasons, they are difficult of cure.

"The *chain of events* in epilepsy and other convulsive diseases may be pursued *link by link.* The eccentric causes act on the *eisodic* nerves, thence on the spinal centre, (medulla oblongata,) and thence along *exodic* nerves on the various muscles. Of these, few, many, or all, may be affected, and the malady may be the very slightest, or the very direst. Amongst the rest — I was about to say, *chief* among the rest — *are the muscles of the neck and larynx.* By the contraction of the muscles of the neck, the veins of the neck are compressed, as I have already noticed, and the extra-cranial and intra-cranial tissues and organs become affected with venous congestion and all its consequences. Nay, I am disposed to say, that in every case in which there is such venous congestion of the neck, face, eyes, brain, it arises from this *trachelismus,* either latent or evident. By the contraction of the muscles of the larynx in laryngismus, — this vital inlet to the respiration, combined, as it usually is, with *breath struggles,* — I believe is the direst form of epilepsy, with its direst effects, as coma, mania, dementia, &c., to be produced. I do not say that these effects may *not* arise in cases in which there is only trachelismus, and no laryngismus; but I am convinced that they are *chiefly* the effects of laryngismus, for they have subsided in cases in which the laryngismus has been disarmed by tracheotomy.

"And now you perceive *in what sense* epilepsy may be regarded as a cerebral disease. Cerebral in its very *origin* it can never be. It may be intra-cranial in its origin, because within the cranium there are many tissues, as the membranes from which eisodic nerves arise — many such nerves, as the fifth pair especially, pursuing there a part of their course; and the *medulla oblongata* also — all of which may be excited by the presence of an exostosis, a tumor, or a variety of causes. But I repeat, that no disease of the cerebral centre, limited to that centre in itself, and *its* effects, does or can produce epilepsy.

"Exciting causes of epilepsy are, then, first — the spinal *system,* the neck — the encephalon. Such are the order or *links* of this

chain of pathology. There remains another, to which I must now draw your special attention: it is the *medulla oblongata*, with its *pneumogastric nerve*. I have already adverted to laryngismus as giving to epilepsy, and to convulsions generally, its most formidable character. This form of laryngismus is *spasmodic* or *convulsive*, and excited through the spinal system.

"But there is another form of laryngismus to which I refer. After a severe epileptic convulsion, the patient is left in a state of *coma*, or, as it may be termed, of *simple apoplexy*. This condition may prove fatal. The respiration becomes stertorous, that is, there is laryngismus. But this laryngismus is very different from that just before described. This is less complete, but more persistent; it is, indeed, permanent. Some one has said, in rather familiar phrase, "the patient snores his life away." This laryngismus is *not* like the former, which was spasmodic, but is *paralytic*. It is owing to compression or congestion — an apoplectic state — of the medulla oblongata, and *paralysis* of the pneumogastric nerve, in which every branch of it, as well as the recurrent laryngeal, is implicated. There is, then, complete *apoplexy* of the medulla oblongata, and *paralysis* of the pneumogastric nerve!

"What phenomena do we observe as occurring in the coma, or simple apoplexy, seen after a severe epileptic seizure? We see *paralytic* laryngismus, impeded respiration, augmented apoplexy. We also observe — or rather I have observed — a *diffused bronchial rattle*, the *effect* of *paralysis* of the bronchial and pulmonary nerve branches from the pneumogastric!

"Here a most interesting phenomenon presents. The cerebrum is *not essential to animal life*. How, then, does apoplexy, simple, cerebral apoplexy, destroy life? It does not do so. Apoplexy only destroys life indirectly, as when by its congestion from downward pressure it implicates the medulla oblongata and its pneumogastric nerve. It is by the apoplexy of this medulla, and the paralysis of this nerve, that life is finally, in effect, destroyed!

"Generally, such a patient dies of *paralytic* laryngismus, or of laryngeal asphyxia. From this danger the patient may be rescued by early tracheotomy. But if the tracheotomy *be* per-

formed, but performed too tardily, the patient, however saved from *laryngeal* asphyxia, dies, after all, of *bronchial* asphyxia. And there are other branches of the pneumogastric nerve that suffer—the cardiac and the gastric. The heart and the stomach participate in the partial or complete paralysis of the general pneumogastric. If the physician observes palpitation as a symptom in some cases of epilepsy, this is explained by being aware of the excitement of the cardiac branches of the pneumogastric. In other cases there are hickups, eructation, acidity of the stomach, the effects of excitement of the gastric branches of this composite nerve, viz., the pneumogastric. Now, as in these cases there is a *morbid action* in the heart and stomach, so in deep epileptic coma, there is *failure* of the powers of these organs.

"The pneumogastric nerve is more involved in epilepsy than it is in other convulsive diseases. For mark, all the phenomena just described as observed in the former, are again met with in the latter, only, of course, modified by the exciting causes and the conditions of age and sex.

"In infants there is the same or similar action of the muscles of the neck, and of the larynx, and of respiration. In puerperal convulsions the symptoms are identically those of epilepsy. There is a form of epilepsy which I have not yet here noticed. It is the *epilepsy syncopalis.* The patient, instead of turning purple, (with congested face,) turns pale and ghastly. Sometimes this syncope is *fatal!* So it is in the *laryngismus stridulus* of infants. The little patient not unfrequently dies suddenly—too suddenly to be the effect of asphyxia. Such a case is cardiac syncopal.

"The laryngismus stridulus is often excited by *enteric* irritation. This is also frequently attended by fret of the bladder. Epilepsy is induced by enteric and by uterine irritation, and is sometimes attended by involuntary evacuations of the bladder, rectum, &c. The urine is frequently found morbid in both cases."

Such are the original views of the great Marshall Hall.

On the treatment of all convulsive diseases, and epilepsy in particular, Dr. Hall advises that excitement and irritants must

be, as far as possible, avoided. The morbid condition of the blood and of the organs must be remedied. A low posture and deep sleep must be carefully shunned. *The neck must be cautiously guarded against a tight collar*, &c. This is all perfectly sound in therapeutics, however questionable may be some points in his theory. (See pp. 222, 264.)

M. Flourens has shown that while superficial sections of the *corpora quadrigemina* produce no other effect than the impairment or loss of vision, deep sections produce general convulsions. "I have been desirous," he says, "of ascertaining whether the parts within the cranium, if excited by the stimulus of galvanism, would give rise to any phenomena similar or analogous to those produced by galvanic stimulation of the spinal cord. Accordingly, I determined to subject them severally to the action of the magneto-electric rotation machine — a most convenient instrument for physiological experiments."

The trials were performed on rabbits. "I took the spinal cord first; here we had the well-known tetanic effects to which I have already frequently referred. Next I tried the *medulla oblongata:* the effects of the stimulation of this organ were much the same as those produced by irritating the cord. I then tried the *corpora quadrigemina* and the *mesocephale.* Having passed fine brad-awls into the cranium, in such a direction as I had previously satisfied myself would lead to this organ, I subjected it to the influence of the machine; general convulsions were produced, of a character essentially different from those which resulted from stimulating the spinal *cord*, or the *medulla oblongata.* They were combined movements of alternate contraction and relaxation; flexion and extension affecting the muscles of all the limbs, of the trunk, and of the eyes, which latter rolled about just as in epilepsy.

"On inserting the awls into the hemispheric lobes of the brain, still different effects were produced by the application of the electric machine. I could observe nothing like true convulsions; but slight convulsive twitchings of the muscles of the face took place, which were no more than what would be caused by the stimulus of galvanism acting upon the nerves of the face.

These experiments, which I have repeated several times, and each time with like results, seem to denote *that convulsions are modified* according to the part of the cerebro-spinal axis which is primarily excited: if it be the spinal *cord*, they are tetanic; if the *medulla oblongata*, they are tetanic likewise, other parts being involved; if the *corpora quadrigemina* and the *mesocephale*, they are epileptic; if the cerebral hemispheres, you scarcely have any convulsions, but slight twitchings of the muscles."

Dr. Weber, in his excellent essay on muscular motion, published in Wagner's "Handworterbuch" of physiology, refers briefly to similar experiments performed by himself on the brain of a frog, and leading to the same results; and he draws this conclusion, that "the *tonic* convulsions, as trismus and tetanus, are the effect of disturbance of the functions of the spinal cord; whilst the *clonic* convulsions are due to derangement of the functions of *certain parts* of the brain." (See p. 222.)

Thus, then, I come to this conclusion, respecting the parts of the nervous system which are directly concerned in the production of the epileptic paroxysm. The part of the encephalon primarily disturbed is the hemispheric lobes; if the disturbance do not go beyond a certain point, the phenomena are limited to simple loss of consciousness and impaired intellectual action, with more or less *sopor*. But if the disturbance be considerable, then the *tubercula quadrigemina* and *mesocephale* become involved, and *epileptic convulsions* are produced. If the disturbance of this centre be very great, the *medulla oblongata* and the *medulla spinalis* become much excited, and the convulsions are complicated with a good deal of the tetanic character. House painters or others exposed to the contamination of *lead* are apt after some time to fall into a fearfully cachectic state, of which a principal feature is the deficiency in red particles of blood. I have seen several persons, under these circumstances, become epileptic shortly before death, and, in fact, die in consequence of the violence of the epileptic paroxysms. All these are striking instances to show how blood, when deficient in quantity, deficient in one of its most important staminal prin-

ciples, (the others, perhaps, not being quite normal,) and, perhaps, contaminated by the presence of some foreign noxious principle, tends to the production of the epileptic state.

Experimental physiology supplies us with very striking facts, to show that simply an *insufficient* supply of blood to the brain is very apt to occasion epileptic convulsions. Every one who has witnessed the slaughter of sheep, which is effected by dividing the great arteries in the neck, must have observed the strong convulsions which so frequently precede death in animals killed in this way. All animals killed by loss of blood exhibit the same phenomena precisely, and die with convulsions of a more or less violent kind. Such facts suggest the *rationale* of treatment for cure, which can be done, in some degree at least, by electric currents. If we follow the views of Dr. Marshall Hall, we find that the diseases of the spinal system exist under several forms, which admit generally of being reproduced in experiments for the purpose; and one great advantage in the study of experimental research in the spinal system, is, that there are thus frequently presented the "*types*" of its diseases.

"In general," he says, "the diseases of the spinal system occur under the form of *spasm*, of *paralysis*, or of the two combined, viz., *spasmo-paralysis*. They are all primarily affections of the excito-motor muscular system, to the exclusion of the sentient or cerebral system — a singular confirmation of a physiological doctrine, that these two systems are totally distinct from each other.

"Generally, spasm consists in *irritation* of nervous tissue, still retaining its normal structure; whilst paralysis implies a *lesion* of that structure. But the structure of the nervous tissue must be viewed under several aspects; thus this tissue may be injured by being lacerated or bruised at any given point; but it may be strangely injured in a given point, by injury inflicted at a distance, through the means of *shock*. In this manner spasm is apt to lead to paralysis, and for the obvious reason that this peculiar lesion is of the most intimate or atomic character, unlike the division or separation of its atoms by laceration, &c.;

the paralysis, or spasmo-paralysis, so induced, is less persistent than in the latter case.

"This remark leads me to the subject of the excito-motor power itself, on which all the movements connected with the spinal system depend. This power may be diminished or even suspended in its energies; it may be also greatly augmented; in which case there is proportionate *susceptibility* to impressions, and to excited actions the results of those impressions.

"The former state of things is induced by all agents of such violent character as produce shock; the latter is induced by peculiar agents, of a chemical or physical character, which act more gently on the nervous structures. The same identical agent may produce either of these effects, indeed, according to its degree. Thus too large a dose of strychnine speedily destroys all excitability; a very minute dose, on the contrary, induces the most extraordinary phenomena of augmented excitability which we can witness. The action of the electric current is precisely similar; a very mild current produces purely physiological effects; too strong a current soon induces destruction of the excitability of this part of the nervous system. The first effect of decapitation (of shock) in a frog, is supension of the excito-motor power; the second and ulterior effect is, or is supposed to be, an *augmented* susceptibility to activity of this vital agent. Electricity, heat, and the class of agents called *stimuli*, generally, may be employed so as to act as augmentative or destructive of the excito-motor nervous power.

"As an example of these effects, I may mention, for the benefit of those who have not performed an experiment, that *immediately* after decapitation of the frog, no reflex actions are produced, on irritating the foot; it is here diminished excitability, the effect of shock. On administering a minute dose of strychnine, on the contrary, the touch even of a feather induces reflex action of a tetanic force and character.

"From experiments we learn that this augmented susceptibility or excitability may exist in *force*, without existing in *action*. A frog may be under the influence of strychnine, yet, if not actually *excited*, it may remain quiescent, relaxed in posture; it is tetan-

ode, without being tetanic, affording a *type* and idea of certain diseases of the spinal system of the deepest interest — one on which the *rationale* of the symptoms and the adaptation of remedies alike and equally depend.

"Now, in this point of view, the effect of strychnine on the frog presents the *type* of hydrophobia. In both the *blood* is poisoned; in both the spinal system is in a condition of extremely *augmented excitability*, without being necessarily *excited.* Avoid all excitation, and the frog recovers. Apply excitation of the mildest character, continuously, and the frog speedily dies; here an experiment accurately presents not only the *type* of the malady, but of the *treatment.*

"In this experiment, as in hydrophobia itself, we have two conditions, one of *excitability*, the other of *actual excitement*, according as excitation is averted or admitted. I propose to designate the former condition by the termination *ode*, the latter by that of *ic*. The frog, unexcited, is still tetan*ode;* excited, it becomes tetan*ic*. The patient affected with hydrophobia is hydrophob*ode;* is he necessarily hydrophob*ic?* The former state admits of recovery; the latter soon destroys.

"In this point of view we may consider other diseases of the spinal system. The patient affected with tetanus is not necessarily tetan*ic;* he is only tetan*ode*. If excited, he dies. What if he were or could be preserved absolutely from all excitement? He dies of violent and exhausting spasms. These spasms are *reflex* actions; reflex actions are necessarily *excited.* Remove all excitation, and the spasms — that is, the cause of death — would be averted.

"In like manner, the newly-decapitated snake is *full* of excitor and motor power, yet free from movement, unless an excitant be applied. So also of certain forms of convulsive disease in infants and in adults. The patients are spasmat*ode* or spasmat*ic*, according as they are excited or preserved from excitement. The difference throughout is that of the *predisposition* to or actual *condition* of, spasmodic action; or that of exc*itability* and exc*itement*. The former may subside, the latter destroys.

"The further difference between hydrophobia and tetanus is,

that the former is induced through the medium of the *blood*, the latter through that of *an incident nerve*. Of the former, the frog affected with strychnine presents the exact *type;* of the latter I doubt whether we possess an *exact type* in any experiment. No experiment has been devised, to my knowledge, to induce augmented excitability of the spinal system through the medium of an incident nerve or nerves, or of any part of the spinal system. It is said that the *decapitated batrachian* is more excitable than the whole or entire animal. But this I think is a mistake. The effects of excitation are *controlled* by efforts of volition in the perfect animal, but are *uncontrolled* in the decapitated animal. The difference, therefore, is rather apparent than real."

Epilepsy.

Epilepsy, according to Dr. Todd, has its primary source or "first cause" *more frequently* in the obviously disordered nutrition of some of the more important organs, and it is most probable that the brain itself, or rather some *portion* of it, is implicated. This can result, moreover, from a great variety of causes, mental or physical; in any case, however, it may then long continue as a mere *disease of habit*, which electric currents may greatly aid in curing. (See Appendix F, Note 2.)

"The pathology of convulsive diseases, as now understood," says Dr. Todd, "seems to show that if the nervous disturbance does not go beyond a certain point, the phenomena are limited to loss of consciousness and impaired intellectual action, and this with more or less sopor. If, however, the disturbance be more considerable, then epileptic convulsions are produced. If there is a still greater or more profound disturbance of the *tubercula quadrigemina*, then the *medulla oblongata* and *spinalis* become excited, and the convulsions are complicated with a good deal of the tetanic character. Looking, then, to the whole assemblage of *ganglionic centres* interposed between the cerebrum and the spinal cord, as on the one hand including the centres of sensation, and probably also of the consciousness of the cerebral operations, as well as impressions on the organs of

sense, and on the other as forming the summit of the apparatus *from which* motions are directly excited, we cannot but think that they are the parts of the encephalon primarily affected, and that the affection of the hemispheres is rather secondary." Although the loss of consciousness and convulsive movements are usually combined in the epileptic paroxysm, the morbid action radiating upward into the cerebrum, and downward into the motor arrangements, either may therefore occur independently of the other. The loss of consciousness is evidently the primary and essential phenomenon in epilepsy; the disturbance of the intellectual functions is obviously secondary and accidental. The *superior ganglion* (pineal) is the focus.

When the epileptic paroxysm is the manifestation of a state of abnormal nutrition of the nerves in some part of the brain, which thus shows itself in an undue development of nerve force, it is, according to Dr. Todd, a disturbance of their nervo-electric polar state; and this, when it has attained a certain measure of intensity, manifests itself in the epileptic paroxysm, just as a Leyden jar, when charged with electricity to a certain state of tension, gets rid of its disturbance by a "disruptive discharge." This state of tension of the brain he regards as resulting "from the accumulation of some material in the blood, which, acting on the brain as a poison, excites this polar state, and this disruptive discharge, and so escapes from the system, leaving the brain sensibly free, until a fresh accumulation excites a new paroxysm."

The nature of the morbific matter, or condition of the fluids, which are found capable of being modified, and sometimes corrected, by the catalytical workings of galvanism, we cannot yet determine. But the resulting *fact* is strongly supported by the following opposite classes of facts, which are adduced for analogy, viz.: —

1. The influence of toxic agents in *producing* artificial epilepsy.

2. The frequent connection of epileptic convulsions, and imperfect elimination, especially by the kidneys, which, when in a still greater degree, is also attended with coma.

3. The correspondence between the paroxysmal character of epilepsy and that of other diseases called humoral, as ague and gout.

4. The introduction of certain animal poisons (as exanthemata) into the system can produce epileptic convulsions; and to these might be added evidences derived from cases of hydrophobia, hysteria, chorea, and tetanus, as occurring also in absence of structural lesions, and in still greater force by those strange manifestations of disordered excitement of the nerve centres which are manifested in *neuræmic* or hysterical forms of convulsions, which always baffle the sagacity of the best physician to satisfactorily account for, and that of the most skilful practitioner to cure.

The diagnosis of the hysterical form of epilepsy is mainly made out *by observing the suddenness with which the several forms give successive place one for the other*, as a choreic for tetanic, and this for epileptic, or paralytic, or perhaps passing off altogether. Thus the strange combinations or successions which they often present mark them from the more settled form of nerve disease that they so simulate.

Dr. Copeland, in his great work, says, "I have not given a *class* of *anti-spasmodics*, because there is really no such class of medicines that possess the property of directly arresting spasms." But probably he had not become familiar with the modern methods of directing the electric current through nerves so as to be an *anti-spasmodic*, as well as an *anti-paralytic*,—not by diminishing their strength, but by nourishing them, and fortifying their power of endurance.

Dr. E. Brown-Sequard is inclined to believe that epilepsy *consists* essentially in an exalted abnormal excitability of certain parts of the cerebro-spinal axis, and in a simultaneous loss of the control that, in normal conditions, the *Will* possesses over the reflex faculty. He has shown that the same cause that produces the first convulsion in some muscles of the neck, the eye, the larynx, and the face, produces also a contraction of the blood vessels in the brain proper, and which contraction is necessarily followed by the loss of consciousness. MM.

Turner and Kussmaul, led by somewhat different researches, arrive at the same explanation. M. Sequard, in reviewing the leading phenomena of a complete seizure of epilepsy, and in giving the *rationale*, shows that we may find they form a *series* of causes and effects much as follows: —

1. CAUSE. *Excitation* of certain parts of the excito-motory side of the nervous centre.

EFFECT. Contraction of blood vessels of the brain proper and of the face; spasm of muscles of the eye and face.

2. CAUSE. *Contraction* of the blood vessels of the brain proper.

EFFECT. Loss of consciousness, and accumulation of blood in the vessels at the base of the encephalon.

3. CAUSE. *Extension* of the first excitation, *partly* due to the accumulation of blood in the base of the encephalon.

EFFECT. Tonic contraction of the laryngeal, the cervical, and the thoracic expiratory muscles, (*laryngismus and trachelismus.*)

4. CAUSE. *Contraction* of laryngeal and of thoracic *expiratory* muscles.

EFFECT. Crying, and stoppage of respiration.

5. CAUSE. *Further extension* of the first excitation of the nervous centre.

EFFECT. Tonic contraction, extending to most of the muscles of the trunk and limbs.

6. CAUSE. *Loss of consciousness*, and tonic contraction in the trunk and limbs.

EFFECT. Falling down.

7. CAUSE. *Laryngismus*, *trachelismus*, and the fixed state of the chest.

EFFECT. Asphyxia, with obstacles to the return of venous blood from the head and the spinal cavity.

8. Cause. *Asphyxia*, and the accumulation of black blood in the encephalon and in the spinal cord.

Effect. *Clonic convulsions* every where, contractions of the bowels, the bladder, and the uterus ; erection ; increase of many secretions ; efforts at inspiration.

9. Cause. *Exhaustion of nervous power generally*, and of the reflex faculty especially, except for respiration, which gradually becomes normal.

Effect. Cessation of the convulsions ; coma, or heavy sleep, after which there is extreme fatigue and headache.

Thus are shown, of course, only the more frequent phenomena, besides which there are a great variety ; moreover, we can thus see the bearing of those admirable researches of Dr. Marshall Hall which first showed the important influence of laryngismus and trachelismus in the causation of epileptiform convulsions. And, finally, we are instructed by Dr. Sequard how *asphyxia*, to which so great a share is due in the phenomena of epilepsy, and in its most grave consequences, depends not only upon the state of the larynx, but also on that of the chest ; and that not only cannot the blood return easily from the head, on account of the trachelismus, but also we see that it cannot enter the chest from either the spinal canal or the head, on account of the fixed state of *expiration ;* besides, the bronchiæ themselves are often contracted, and thus, all these causes co-existing, the blood accumulates and lingers in the base of the encephalon, also in and about the spinal cord, *from ganglionic reflex-action.*

According to Dr. Sequard, there are many other nervous affections that very often have the characteristic features of epilepsy, at least as regards their *production.* He relates a large number of facts that go to show and prove that, far more frequently than might be imagined by most persons, there are many forms of insanity, of vertigo, of hallucinations, of illusions, and also of ecstasis, catalepsy, hysteria, chorea, hydrophobia, tetanus, (lockjaw,) local cramps, and even that peculiar diffusible paralysis that is connected with insanity, which may be due to irritations "*starting*" from a centripetal nerve rami-

fication that is frequently but slightly felt, or even utterly unfelt; that the suppression of this local irritation may as promptly as surely cure the patient, just as is done in cases of true epilepsy.

In accordance with this view, he advises that the precise condition of all the surface and organs of the body should be most carefully inquired into. If the unfelt *aura* starts from some part of the skin, or from some organ not deep seated, — as the testicle, for example, — or some part of the mucous membrane *near* the skin, either the first "*contractions*" in a fit, or the most violent, or the most prolonged, *are found in the neighborhood of the point of starting of the aura.* If no indications of this can be furnished by the persons who have seen the fits, it will be well, says Dr. Sequard, to apply a very powerful galvanic current, with dry electrodes, on the various parts of the skin, about the time *when the patient expects to have the fit.* He says he has in this way discovered the very "*point of departure*" of the aura that had been entirely unfelt by the patient, and undiscovered by the medical attendant.

If this test is resorted to, I would advise rather the employment of electro-magnetic or magneto-electric currents, as strong as the patient can bear, using metallic ball electrodes as *team electrodes*, i. e., held side by side, and thus moved along over the suspected region, in the first instance, much as localized Faradaization; but if no aura is thus "scared up," then the appeal can be made through reflex action, and this can be greatly multiplied by widely separating the electrodes, using larger ones on moistened skin, and directing the current for a few seconds inversely, and then as long directly. But these testing, "searching" applications should never be continued, in any epileptic case, at any one *seance*, more than two minutes.

As regards the treatment of epilepsy, and kindred affections, therefore, we are to direct the most powerful "*alteratives*" *of nervous nutrition*, whether it be electric currents, setons, moxas, or shocks produced by the daily *double-bath* of first hot and then cold water, — aided by the nerve-polarizing or depolarizing medicine, such as iron, iodine, and sulphur; or silver, arsenic,

strychnine and quinine; or opium, conium, stramonium, nicotine, or belladona,—in some way, by some of these means, always aiming to bear as directly as possible on the identical spots or parts of *exalted excitability*, both at the peripheric nerves and nerve centres, to strengthen and calm them.

The *rule* is, then, first, to find out if there is any *external* cause acting persistently or periodically upon the nerve centres; next, to intercept or prevent this irritation from reaching the centres, or rather to *destroy* this cause, whatever it may be, for according to the more recent researches, this is found very frequently to exist. When the spot of *aura epileptica* is discovered in the sentient nerves of the skin, treat it just as if a severe neuralgic point, i. e., by a *direct*, continuous current. But the source of the aura may be from the ovaries, the stomach, or bowels, or come through the eye, or the mind. If not discoverable, and the patient is robust, then apply the continuous current *down the spine*, and repeat it every other day.

Asthma and Angina Pectoris.—Of both there are cases that are purely nervous, and are radically cured by the skilful employment of electric currents. M. Duchenne remarks that it is the *fit* in angina that kills; therefore the work to be done is first to prevent its return, or to break its force when on. His practice, it seems, is to apply, during the fit, a small sized electrode to each of the nipples of the breasts in man or woman, with a full current of electro-magnetism, which of course was painful; but this he finds will break up the agonizing attack, and cause it, together with the other varied phenomena that attend it, to disappear at once. Then, in after days, some cautious Faradaization practised from time to time over the still existing painful spots on the thorax chases away the remaining angina. Such are the directions of Dr. Duchenne.

According to my own most successful experience, angina is simply to be treated as if a neuralgic spot; and if uncomplicated with organic disease, and the habits of the patient are all correct, the cure is almost certain. But for asthma there must be a *modifying* impression made on the nervous centres, as well as on the peripheric nerve twigs. I therefore direct, first, an up-

running current *from* the pit of the stomach and along the region of the diaphragm, from the sternum and the pectoral muscles, *to* the posterior cervical ganglion, for two or three minutes, and then *down the spine* with a stronger current, for five or six minutes more at each seance. (See Appendix D,1; F, 2.)

Chorea — "St. Vitus's Dance."

The characteristics of this odd affection are, mainly, irregular and involuntary motions of one or more limbs, and also often of the face and trunk. These twitchings or spasms *do not* continue during sleep. This disease more frequently occurs from fright, before puberty, but not always or necessarily so, and is believed to be connected with enfeebled nerves, and some torpor of the developing system. Its duration may be long as a mere nerve habit, or it may lead on to deformity and idiocy; but it is rarely fatal. Active purgatives once or twice a week, as by *oleum tiglii*, and the persevering use of iron, or of arsenic, as in Fowler's solution, will often cure it. But the primary and direct or down-running current of some ten elements of Daniell's batteries, applied every other day to the spine, with all the precautions and method as laid down for the treatment of neuralgia, will materially aid in arousing and equalizing the nervous energy of the system. Particularly is this true where the chorea occurs in a constitution tainted with rheumatism. But as "St. Vitus's dance" is now and then attended with a heart affected, of which it may be a symptom, it is always well to examine that organ before commencing the use of electro-therapeutics for the cure of this nervous affection.

My own clinical experience enables me to say, moreover, that where the heart *is not* seriously diseased, and very often, where it *is* greatly disturbed in function, I have scarcely ever failed to cure chorea, even when of ten to twenty years' standing, by means of the direct primary currents of galvanism, run from the nucha to the coccyx, in connection with the *cold douche* to the spine, daily, and continued for a length of time.

Dr. Addison, the senior physician to Guy's Hospital, says,

"Whenever I see a young subject the victim of chorea, I always suspect that it has its origin in rheumatism. Believe me, rheumatism is a very eccentric disease; I know of none more so. There is no disease of which we know really so little as of rheumatism in its pathological essence and nature. An old physician of great celebrity was asked, 'What is the cure for an acute attack of rheumatism?' His laconic answer was, 'The cure for an attack of rheumatism is — *six weeks;*' that is, it is not cured. Let us, however, at all hazards, mind the *heart* in these cases.

I am satisfied as to the ravages committed by this rheumatic poison in the endocardium and pericardium, and that too often without any pain to attract attention. This pericarditis is of a marked kind, for it may occur stealthily, with no pain about the heart.

There are other curious associations between the brain and the heart, here to be noticed. "Epilepsy, for instance, affects the heart, as it sometimes shows itself in a violent fit of *tumult* or palpitation of the heart, with unconsciousness — *epilepsy of the heart.* Emotional influences will produce palpitation of the heart; the emotional influences of fright will cause chorea; indeed, this is *the most common* of all causes of this affection. A dog runs after a child; a ghost story is told by a foolish nurse; a house takes fire; the child is exposed to danger, or perhaps is seized by a stranger, or is flogged by the school teacher, or some horrible agitation is set up in the emotional (or central) parts of the brain, and a choreic state is the result. The fact is, the complication or 'connection of chorea with rheumatism and *heart disease,*' is so frequent, that I always look for it.

"While speaking of the heart, let me remind you that in case there is found a lurking *inflammatory* state of the heart, as endocarditis or pericarditis, whatever else be your treatment, let your patient lie for whole weeks upon his lounge or bed, for although we cannot give the heart *perfect* rest, it is all the more necessary to give it as much as we can. Keep the action of the heart quiet; give tinct. veratrum viride, and avoid stimulus, but give valerian tea and morphine at night, to insure rest, and such cases do then, under galvanism, finally recover, even where apparently most hopeless." Such are the views of Dr. Addison.

We can scarcely ever see a case of acute chorea, therefore, without at least carefully examining for a rheumatic history. If there be no fibrile state present, but if the urine is found highly loaded with lithates, though not of itself sufficient, yet it is highly presumptive of the co-existence of rheumatic discrasia, and perhaps of acute pericarditis also. A great number of examples might be delineated here, to show the success of a weak primary or a very gentle secondary current, directed for five minutes per day *down* the whole spine. Dr. Dupee, of this city, sent a little boy, Charles C., under a dozen years old, to me, for this treatment, whose heart was not only affected, but together with chorea, the saliva drooled from his mouth, his speech was nearly gone, and his right arm was quite paralyzed. I gave him daily sittings for the first month, (Sundays excepted,) then two sittings per week, for the next month, which quite completed the cure. This fine little fellow is now well and at school.

According to M. Becquerel, too, this affection is susceptible of receiving a happy and permanent influence, if we employ the primary current of some ten Daniell's compound battery, gently applied and directed down the whole length of the spine, by placing one electrode at the base of the occiput, while the other is at or under the coccyx; or we may employ negative sparks, drawing them from along the spine. The former, he says, where the chorea is *not* still the consequence of worms, nor yet of some existing organic disease, as of the heart, &c., has a most rapid catalytical in-working, much as in cases of rheumatism, and resulting in most complete success, alike in cases of local, general, and hemiplegic forms.

It ought to be mentioned here, likewise, that where "*stuttering*" occurs in childhood, or if the patient is still in youth, electricity can restore *power* to the muscles and *dominion* to the will, which, together with muscle drill and muscle education to break up the old and bad habits of the muscles, will constitute a radical cure. For these cases we can employ the negative sparks of static electricity directed daily to the muscles under the chin and about the throat, or the Faradaic currents run *from* the posterior cervical ganglia *to* the throat and roots of the tongue,

at the same time instituting a daily exercise in the practice of counting deliberately, and repeating or reading words of monosyllables with commas between.

Cramps.

Cramp is truly a *muscular* affection, arising usually from *undue fatigue*, or even from causes remote in the system, as indigestible matters lodged in the alimentary canal can cause cramps in the legs. Hence the *causes*, in such cases, are to receive our first attention. These may even be cholera morbus, or colica pictonum. These sudden and highly painful contractions of a muscle or bundle of muscles are temporarily relieved by friction, and firm pressure over the spasmed muscle fibres, or by a ligature applied around the limb above the affected muscle. This may and does occur sometimes in the muscular structure of the stomach. There may be a troublesome, nervous cough in one case, or sneezing in another, or yawning, or twitching, or tremulous eye-winking. Now, all these are but varieties of *clonic* spasms — an irregular contraction of certain muscles. Sometimes hickups set in after some severe accident, from the profound jar of the nerve centres, and continue for weeks, and yet the patient may recover under proper treatment. Place the positive electrode on the upper part of the spine, and with the *labile* negative, *bathe* the waist and all the lower thorax muscles with a smart current of electro-magnetism. If the cramp is in the muscles of a limb, first embrace the affected muscles between the electrodes, say for a minute or two, then remove one above the seat of spasm, using only a direct or down-running current of considerable strength.

Tetanus, when idiopathic, or continuing even as the sequel of a traumatic origin, provided the thorn, nail, or sliver is removed, or the included nerve is released from the accidental embrace of a ligature, may be sometimes successfully treated by Faradaic or Galvanic currents, carefully and continuously *directed down the spine*. Dubois Reymond, however, thinks that the current does not penetrate to the spinal cord, unless the

current is great, or is interrupted, or reversed; neither of which is under any circumstances allowable. True, I cannot speak from any satisfactory treatments of my own, as yet; but from what I have observed, I certainly should apply the primary *direct* current of galvanism to such a case, and perhaps a very gentle, even, and long-continued current of electro-magnetism, down the spine, and from the coccyx down to the foot, if the first cause had *not* been there situated.

Hysterical convulsions, cramps, and rigidities are proper cases for the electrical treatment, and are usually benefited by it. Sometimes, and that not seldom, the exalted hysterical phenomena are quite *annihilated* by this means, so that these cases may be said to be permanently cured. In these variegated affections, the testimony of Dr. Becquerel, as also of Drs. Meyer, Remak, and others of high authority, goes to show the uniformly good effects of electric currents in all such cases, *when well directed;* and this is as might be expected, because neither the motor nerves, nor the cerebro-spinal axis are in any way injured. But here we must never employ sparks, shocks, nor interrupted or reversed currents. Treat all such cases as if neuralgia, by running the primary or very even and gentle secondary current *down the spine*, or down the abdomen or limb at first; then try to bring both electrodes below or beyond the site of the cramp, with a very carefully managed direct current cautiously applied, long retained, and as carefully removed. (See F, Note 2.)

Agitans, or "tremblings" from the poison of alcoholic drinks, as more frequently seen after delirium tremens,—muscle and limb tremblings from the poison of mercury, opium, lead, or arsenic,—and the tremblings of exhausted muscles, as from protracted monotonous work, or from premature old age, are greatly benefited by bathing all such extremely enfeebled nerves and muscles or limbs with a brisk current of Faradaism. To this end, employ the *team electrodes* by ceaseless (*labile*) movements, and this to be followed by the gentle frictions, strokes, and smoothings of the palms of the hands; then cover with fur or flannel. If this is carefully performed daily, yet not overdone, the restoration is remarkably uniform, speedy and complete.

Chills and Fever.

Ague, (from Gothic *agis*, "trembling,") and all the shades, phases, and degrees of this class of morbid nervous phenomena, —from the masked or "dumb ague," and *the chills*, to true intermitting fever, and even the *congestive* forms of bilious fevers as they occur in the great valley of the Mississippi,—for disturbed conditions of the vaso-motory and nervous system, electro-therapeutics, *when employed at the right stage*, and in the right method for the given case, even when complicated with accouchement or accident, must now be reckoned as among the more potent, important, and grand remedies. The electric currents *can be so employed*, if the general principles laid down in this work are observed, as to "break the chill," to anticipate and annihilate the *habit of its periodical recurrence*, and for reëstablishing and fortifying the nervous system with its accustomed powers of endurance. For spleen enlargement, or *ague-cake*, for the congested and sluggish liver, and for torpidity of the stomach, pancreas, kidneys, and intestines, the *electrodes*, *in skilful hands*, become, *in effect*, an *argumentum ad hominem;* they are indeed the very mainspring and power of all the train of medication. (See Appendix F, 2.)

Treatment.—First, the *place:* the patient, we presume, is in bed, in a room where the air is *dry* and warm, (not sitting up before the blaze of the fire, nor where a draught of wind is allowed to blow upon any portion of his body or limbs.) Second, the *time:* just a little before the hour and minute for the invasion of the cold stage, *shake*, or rigors, is the time to work. Prepare the patient comfortably; wet the sponge electrodes in *very warm water*, or salt water, and see that the battery or machine works well; then commence *before* the *horripilatio* of yawning, stretching, sighing, "cold chills down the back," goose-flesh, and collapse of the features, *get the start*, (as in Faradaic tooth-extracting,) and maintain it, first, by a current from the nape of the neck to the regions of the liver, stomach, and bowels; next up and down the back; and then using *team-electrodes* to Faradaize the surface. When the chill is broken, repeat a daily *seance*, but at different hours, to fortify the invigoration. (See pages 54 and 694.)

CHAPTER IX.

MIDWIFERY—ABDOMINAL VISCERA—SECRETIONS.

THE uterus may be contracted by a given application of electricity, whether gravid or not. Clinical experience, of late, has fairly demonstrated that by the employment of the Faradaic or Galvanic currents, the uterus in the living woman contracts *in toto*. Recently, Dr. McKenzie, of England, exposed to view, as is well known, the gravid uterus of a pregnant bitch, and then, by means of the electro-magnetic currents applied in a certain way, he perceived, after a given time, a slow vermicular-like movement of the muscular coats of the uterus, which resulted in general contractions. This was also perceptible to the touch of the fingers. The phenomenon was far more marked when the *positive* pole was applied to the spine, while the *negative* pole was being applied to the cervix uteri, than when both electrodes were directed to the substance of the uterus. He ascertained that an electric current directed perpendicularly, i. e., in a direction through the uterus from the fundus to the cervix, promotes powerful and general uterine contractions; whereas currents passed transversely through the organ excite but partial contractions, and those limited to the fibres embraced between the electrodes. *Dr. McKenzie insists that it is necessary to apply the positive pole to the nape of the neck, while the negative is at the cervix uteri, if we wish to act surely and energetically through the great sympathetic, upon the contractile fibre-cells of the involuntary muscular substance of the uterus, in any great emergency.*

Herder, Stein, and Kilian in Germany, Radford and Barnes in England, and Bertholon in France, have employed, and still recommend the employment, of electricity by induction, as aid to midwifery practice; especially so in cases of tedious labor; in

some forms of *placenta prævia;* and for *atonic* hemorrhage from the uterus *post partum;* also for originating uterine contractions where necessary to induce premature labor. Dr. Cleveland, of England, we notice, advises to apply the sponge electrodes over the surface of the abdomen, only changing their site from time to time.

After all, Professor Simpson, of Edinburgh, is rather of the opinion that electricity in midwifery practice is all but useless; for, as he thinks, whenever uterine contractions have been *apparently* excited by any electric current, the phenomenon was rather a coincidence; or else it resulted from the impression that is made upon the mind of the patient; or else is produced by the mechanical irritation of the uterus, or of the surface of the abdomen, by manipulating with the electrodes. At least, such were his conclusions a few years since. Now, if these electrodes were a kind of "Perkins's Tractors," as some one has before suggested, we might be necessitated to find a mere occasional *coincidence*, or some show of reason for an occasional effect; but, when we recollect that these electrodes are no inert things, but actually convey a power that controls all living muscular fibres, both of voluntary as well as involuntary muscles, and contractile tissues also, (more slowly, it is true, but as surely,) and when, from a given strength and direction of current, employed under given circumstances, on different portions of the body or limbs, we uniformly find certain results, I can see no force in these reasons, further than an opinion. Certainly, it is contrary to the whole drift of evidence in my own experience in midwifery practice. There are very many women who become exhausted before the labor is terminated. There is a state of temporary inertia sometimes, *that must be aroused sufficiently for the emergency.* Electricity is better for this than ergot, according to my own experience. There are others, also, where ergot of itself will not suffice, but resort must be had to instruments. Here, too, I have found electro-magnetism better than lever, hook, or forceps. It appears to me to be as safe and effective as it is painless, if correctly and patiently applied. If there is plethora, or any active inflammatory condition, it will not succeed. If it is very

long applied, say for hours together, it will *increase* the atony, rather than relieve it. In extreme *inertia*, it will fail because there is nothing to arouse. It is here contra-indicated. Indeed, it is a *rule* to be scrupulously observed, the more feeble or exhausted is the patient, or the more protracted the inertia has been, the more careful we must be not to prolong the application very far — certainly not a moment beyond the attained contraction or suspension of hemorrhage. But in some atonic and hemorrhagic states, not attended with plethora or inflammation, and not otherwise contra-indicated, we can *rely* upon electricity, when skilfully employed, to be of most signal service in saving life-blood, and even life itself. (See Appendix E, F, G.)

Dr. Swan, and also Dr. Robert Remak of Berlin, in 1839, expressed the then prevailing opinion that the human heart and uterus possessed very few and very small nerves. But Dr. Robert Lee has demonstrated in the 41st and 42d volumes of the Philosophical Transactions, that there are nerves, which he illustrated by three engravings, showing, on these organs, numerous great ganglia and plexuses of nerves. He says "these enlarge with the coats, blood vessels, and absorbents during pregnancy, and which return after parturition to their original condition, as before conception. Recent dissections which I have made of the ganglia and nerves of the virgin and of the gravid uterus have enabled me not merely to confirm the accuracy of these descriptions and delineations, but to discover the still more important anatomical and physiological truth, that there are ganglia situated *in the muscular substance of the uterus* and plexuses of nerves, which accompany all the arteries, veins, and absorbents, distributed throughout its walls. It is demonstrated by these dissections that there are not only great ganglia at the neck and on the body of the uterus, but ganglia between the strata of the muscular fibres, and that the whole muscular and vascular structures of the uterus are pervaded with ganglia and nerves. If the dissections which have been made of the ganglia and nerves of the virgin uterus be compared with those of the gravid uterus, it will be seen that the nervous structures of the uterus enlarge during pregnancy upwards of seventy times."

If we here follow the original views of Dr. W. T. Smith, we see that the plexuses of the abdomen, like the external plexuses, are simply mechanical adaptations for mixing nervous fibres and communications from different sources, and applying them to the uterine nerves, it becomes a possibility, and I may say a *probability*, that the uterine nerves are more variously derived than any other nerves of the human body. They may be derived from different points of the great nervous tract between the origin of the pneumogastric nerve in the *medulla oblongata*, and the origin of the sacral nerves in the *cauda equina*. There is, moreover, no actual impediment to the approach of nervous fibres to the uterus from the medulla oblongata through the medium of the *vagus*, or from the cervical portion of the spinal marrow by the *phrenic*, or from the thoracic by the splanchnic nerves, and from the dorsal by the compound lumbar branches of the *sympathetic* and the sacral nerves, which latter come directly from the spinal cord. Dr. Smith gives the following physiological proofs of the existence of a large supply of nerves to the uterus. He says, —

" There is no doubt that the uterus is susceptible of pain; this is one proof of a nervous connection between the uterus and the brain as the organ of sensation. No one doubts that an emotion of the mind may excite the uterus to powerful contractions. This is another proof of nervous connection between the brain and uterus. No one denies that, during pregnancy, the uterus affects sympathetically the most distant organs, producing the changes in the mammæ, and the gastric disturbances, which are so universal. These facts are explicable by the existence of nervous communications between the uterus on the one hand, and the stomach and mammæ on the other. There is no other route than that afforded by the nervous system. No one denies, either, that after parturition, the breast or the stomach may excite the uterus to action; these facts further prove a reciprocal influence *from* the stomach and breasts *to* the uterus. Such facts are, in their sphere, as convincing as though the eye could see a great concourse of nerves running between these organs. A physiological fact is worth quite as much as an ana-

tomical fibre. These communications can only take place through the medium of nerves, and whether there be one channel or many, whether the chief place be given to the spinal fibrillæ of the sympathetic, or to the proper nerves of the spinal cord, the necessity for uterine nerves is equally inexorable. There *must* be nerves, and there must be nerves *sufficient* for the functions to be performed. Anatomical facts can never give the lie to the facts of physiology."

There are three modes of exciting contraction of the uterus. Reflex contractions may be excited, says Dr. W. T. Smith,—

1. By stimuli applied to the mammary nerves.

2. By stimuli through the medium of the pneumogastric nerves, as when food, hot or cold drinks, ergot or emetics, are taken.

3. By stimuli directed to the spine, and the abdominal or intercostal nerves. The latter, he thinks, is the first and best.

The cutaneous nerves of the abdominal parietes are excitors of the uterus in an extraordinary degree. The sudden impression of cold or heat, or both in quick alternate successions, upon the abdominal surface, will almost always excite the most energetic contraction of the uterus, when affected with *inertia*, and from which, perhaps, hemorrhage is taking place. We may contract the relaxed and diffuse uterus to a firm ball, by *douching* the abdomen with cold water from a height, or by splashing a towel, taken out of cold water, upon the naked abdomen, or by suddenly placing the hand, just taken out of iced water, upon the umbilicus. If the surface of the abdomen should be cold, the sudden impression of heat produces similar contraction. In all these instances it is the *reflex* actions from the extremities of the cutaneous nerves of the abdomen which are affected by the stimuli. The result takes places too instantly to permit the belief that any sensation of cold or heat passes through the abdominal parietes to the uterus itself. The extremities of the cutaneous nerves of the abdomen are, in fact, almost as distant from the uterus as the superior intercostal nerves which supply the mammary glands. As to the true mode of action from irritation of the mammary and pneumogastric, and the abdominal

intercostal nerves, there can be no doubt left whatever. These nerves are too remote from the uterus, in their peripheral extremities, to admit of any other explanation save that of the *reflex* function.

But what I wish to insist upon is this — that all the actions I have been describing are *reflex* in their nature. Physiology repudiates the idea of uterine contractions excited by means of continuity or contiguity of the organs excited, with the organs which contract. The peripheries of the nerves of the bladder, rectum, vulva, and vagina receive the impression through the incident nerves and the spinal centre, while the motor nerves of the uterus, distributed to its muscular structure, are all concerned in the muscular contraction which ensues. Though the organs excited are near the uterus which contracts, the route of the nervous action is precisely the same as it was in the case when the stimuli were applied to the mammary or the pneumogastric nerve. I make these observations because I still see the obsolete notion, which so long perplexed physiology, of referring all such actions to the sympathetic nerve, and to the mere anatomical distribution of nerves to neighboring organs from the same source, cited by some authorities as sufficient to account for all such motor phenomena as those which take place between the different pelvic organs respectively. They look only at the nerves interlacing and communicating with each other, and their minds do not reach to the necessity of considering the spinal centre as the organ which connects the roots of motor and excitor nerves, and *provides the power*, as well as a way-station "*ganglion*," for prompt nerve-telegraphing.

The Uterine Nerves. — The power we possess over the uterus by this means is very great indeed, and the modes by which we can exert it are very various. We may excite the nerves of the external surface of the uterus, the nerves of the internal surface, or the nerves of the *os uteri*, respectively. When, for example, we produce uterine contractions by irritating the uterus through the abdominal surface, we act on the first series of nerves; when we inject cold water into the uterine cavity, or introduce an electrode, we act on the second; and when we

irritate the *os uteri* by digitation, we act on the third. These measures, as well as this knowledge, are of great importance in our attempts to arouse the uterus itself to action. Now, in all these varied actions, the excitor nerves, the spinal centre, and the motor nerves are concerned. The uterus does not contract simply and singly from any inherent power belonging to the organ itself. Its actions from these sources of excitation depend mainly on its connection with the spinal marrow. Doubtless there are other forms of action mixed up with those which are purely *reflex*, and to these I shall presently revert; but what I would contend for is, that much of the uterine action consequent upon irritation of the uterus itself is as strictly *reflex* — as much produced through the medium of incident and motor nerves, and the spinal centre — as are the uterine actions caused by irritation of the mammary or rectal nerves. This is what I cannot too much insist upon. (See Appendix E, Note 2.)

But again, this is illustrated in the case of the stomach; for there are other medicines — the potassio-tartrate of antimony, for instance, which acts as an emetic only after it has been taken into the circulation, and which acts more promptly when injected into the blood itself. I believe the action of this medicine to be perfectly analogous to the action of the ergot of rye; that the one acts upon the *medulla oblongata* and the motor nerves of uterine action. The ergot, therefore, is a remedy of centric utero-spinal action. We shall presently see that these inquiries into the mode of action of remedies are not without a practical use. The ergot, in addition to its utero-spinal action, sometimes produces vomiting, thus affecting the *medulla oblongata*, as well as the lower segments of the spinal centre; but it is remarkable that, though an excitant of motor action in these instances, it diminishes the frequency and force of the heart's action. This action of the ergot is favorable in some cases of hemorrhage, but unfavorable in others, as where failure of the circulation, and dissolution, appear to be imminent.

Moreover, Dr. Smith speaks of "the different modes of exciting uterine action by stimulating the muscular irritability of the organ," as distinguished from the excitement of muscular

action through the nerves. He mentions three methods by which this is performed — the application of cold, mechanical irritation with the hand, and the use of galvanism. With regard to the latter, he says, "We find that in patients perfectly paraplegic, with entire loss of reflex uterine power, yet the uterus has been excited to contractions sufficient to expel the fœtus by means of electro-magnetism. Dr. Radford, of Manchester, applied this power to the arrest of uterine hemorrhage. One pole of a galvanic trough being placed *within* the os uteri, and the other applied over and above the fundus, it has been found that on making and breaking the galvanic circle every half minute, powerful uterine contractions occur. It is said that the uterus can be made to contract by this agency when it will obey no other stimulus whatever, and I have little doubt that this is correct. It accords with all we know of the influence of electricity upon the muscular fibre. The contraction of the uterus from galvanism is probably the most simple mode in which we can act directly upon the irritability of the muscular fibre, and the contained ramifying nerve fibrils, without necessarily complicating it with reflex action, (if this is so in fact.) The reflex actions excited by passing galvanic currents through muscles alone, we know, are very slight, if they occur at all. This is proved by a great number of experiments. There is, however, one important disturbing agency in the application of galvanic currents, which must be taken into account. The application of this remedy, and the painful sensations it excites, disturb the emotions considerably. In some such cases, the emotional excitement increases the influence of galvanism; in others, it weakens or suspends its sensible action altogether. This is probably one of the reasons why, in some cases, galvanism produces little or no contractile effects."

Prolapsus Uteri. — In the Edinburgh Medical Journal for 1856 we find the following editorial on the *Displacements of the Womb:* "It is our impression, that there is not a sufficient regard to the recognizance of the uterus as a 'floating body,' or rather as a body whose mechanical conditions of equilibrium make its support more nearly analogous to that, than to any

other mode of support. The most considerable *solid support* to the uterus is the vagina. These two conditions lead to an easy understanding of many phenomena of the minor motions of the uterus, called misplacement, or displacement. The failure of the vaginal support through relaxation (amounting sometimes to a sort of paralysis) of the vaginal tube, and often accompanied by a similar condition of the rectum, leads to the most complete displacements of the womb while healthy *in itself*, and leads also to all the ordinary symptoms of uterine ailment in the most aggravated forms, which are curable *only on conditions of curing the vagina.*

Again, enlargement, and consequently increased weight, of any part of the uterus, leads to a falling or sinking of it. Enlargement of the cervix leads to depression of the organ. Enlargement of the body, causing top-heaviness, leads to retroversion or anteversion, or flexion. It is nearly certain that the ligaments of the uterus have almost no function as ligaments, but quite the reverse; and that in those cases of displacement where symptoms of dragging are ascribed to them, there is, *in fact*, no such dragging at all. The uterus has free motions afforded to it by these ligaments, which are not to be put on the stretch by any ordinary misplacement. It must also be remembered in regard to uterine flexions, that the organ is sometimes so softened as not to be capable of bearing its own weight — a circumstance sometimes connected with leucorrhœa, and symptoms of pain." (See p. 475, and Appendix E, 2; F, 2.)

Here, evidently, are a class of ills peculiar to females, that, in a rational sense, ought to be greatly amenable to the power of electro-therapeutics, — and so they are. If I should report the contents of my case-book under this head, it alone would make a volume of no small interest.

Amenorrhœa.

The methodical use of electricity is of inestimable value as an *emmenagogue* in young women, where the menstrual function has not appeared, or where it is not fully established in conse-

quence of a want of action through the vaso-motory nerves of the ovaries and uterus. No less important aid is rendered by Faradaic currents for those young females who are threatened with phthisis, by determination of blood to the lungs, or where there is a vicarious hemorrhage or discharge. For these, I can testify that the Faradaic *seance* comes to the aid of the practitioner, in a professional sense, "as a very friend in time of need." I would not be understood to claim for it unfailing success, even where there are no morbid changes. Yet I can say that it is so frequently, and indeed quite uniformly, successful, — coming to the rescue when the ordinary and extraordinary means have long proved not quite sufficient, — that no physician can now afford to be without this excellent therapeutic at his command.

A curious case is mentioned in the New York Journal of Medicine, 1844, by Dr. Le Conté, of the south. He states that a woman, more than seventy years of age, residing on a plantation in the State of Georgia, who had ceased her menses for more than twenty years, on being struck by lightning, her menses were completely reëstablished, and continued with the utmost regularity for more than a year after the accident. During the same time her breasts were enlarged much as they were in early life.

The best "methods" of treating amenorrhœa by electricity is a question, since different great authorities advocate somewhat different plans. M. Becquerel admonishes us, in the first place, not to employ electricity at all, for this or any other disease in the female, "*during the catamenial flow*," as it is very liable to put a stop to it. I would call particular attention to this remark of Becquerel; so much do I regard its importance, that it has been a very *rule* with me in all electro-therapeutic applications.

In Guy's Hospital, electricity is considered not only admissible for treating these cases, but moreover *as the only true and reliable emmenagogue we possess*. Yet it is by no means to be used here exclusively, any more than in any other case. When visiting that hospital, I observed that they mostly em-

ployed static electricity, giving the patient a dozen or so of shocks at each *seance*, from a quart Leyden jar, fully charged, and directed through the pelvic region *from* the lumbar or sacral spine *to* the *symphasis pubis*. By the reports of that hospital for the past fifteen years, it appears that this has been the *chief reliance* when the condition of the organism was right for its use, or had been prepared by iron and tonics, and that out of twenty-four cases of amenorrhœa twenty of them were thus cured. Dr. Duchenne in France has also been very successful with this class of patients, using invariably strong electro-magnetic currents locally applied, i. e., to the uterine organs.

It is, I think, now a well-authenticated fact, that the application of a brisk electro-magnetic current to almost any part of the body or limbs, if about the *period* of her menstrua, *is liable* to induce a flow of the menses in any female that is at the time in a physiological state *capable* of that function. In treating these affections, it is always advisable to make such trials as will most possibly spare the moral sensibilities of our youthful patient. To this end, direct that a large moist sponge electrode be applied by herself or attendant to the groin, or *perinæum*, (which is better,) or to the upper inner side of the thigh, while the other electrode is carried by the operator's hand to the lumbar and sacral regions of the back. This last electrode should be the positive, and at high speed, while the tip of the conductor may be repeatedly touched, and for a few seconds retained, to the binding screw of the machine. Thus we are enabled to *shock* the patient, to increase the circulation in the uterine region, and to arouse the functions there to life. Generally speaking, I prefer maintaining one electrode somewhere up or down the spine, even on the *nucha* or under the *coccyx;* let the other be where you please — over the pubis, vulva, or perinæum, or in the vagina, or above the groin on either side. Never remove the electrodes until the *seance* is through, but suddenly break and make the contact at the binding screw, also reversing the current direction now and then, (provided she is not a nervous person.) By this means we

find we can shock nearly as well as by a Leyden jar, and the patient can bear it daily. I have said that electro-magnetism is our great ultimate emmenagogue; also that it will *as surely stop* the menses if applied to the female *during the flow*. But I must add, that in cases where the flow is tardy, pale, or but partial, then, too, by this agent can it be increased in quantity. and quality, and become prompt. (See Appendix E, G.)

Case of Chlorosis. — Miss E., nineteen years of age, graduate of one of our highest and most fashionable female seminaries, but with decidedly enfeebled health. Her general appearance is that of a very beautiful girl, *minus* color and vivacity; for she is remarkably well developed and plump, but fair and white as marble, lips and gums blanched, tongue pale, wrinkled, and indented, and her eyes languid. She came under the care of Dr. Edward H. Clarke, who, after finding that tonics, nutriment, and chalybeates, together with out-door and horse exercise, and the cessation of study, did not stay the anæmic and declining tendencies in this girl, therefore sent her to me to receive such *electrical treatment* as I might judge to be advantageous in her case. There was distinct systolic bellows sound of the heart; urine was about twelve ounces in every twelve hours, which was rich with albumen, epithelial casts, and crystals of the triple phosphates of ammonia and magnesia, and there was long-standing amenorrhœa. She was greatly troubled at times with intercostal neuralgia; had a hacking cough which besieged her severely on retiring to bed, but there was no expectoration; her lower limbs from ankle to knee not any way anasarcous, but were peculiarly plump, fair, and polished, as if beautiful statuary.

The electric treatment of this case was commenced, therefore, with the view of first increasing the capillary circulation, and the endosmodic and exosmodic process. To this end I employed first a smart current of Faradaism, and then that of Galvanism, at each *seance*, which was repeated daily, using large metallic ball electrodes covered with wet wash-leather, with which the surface was gradually gone over, holding the balls as *team electrodes*, (with only one or two fingers between them;) and then by polar alternations, labile movements, and sudden current

reversing, I caused the muscle fibres to contract, and this with redness and heat wherever the electrodes were applied and swept along, which was done over the whole back at one seance, for example, then over the lower limbs at the next, &c. At the same time this patient remained under the mutual watch and care of Professor Clarke, who simply advised a diminution of medicine, but a continuance of the same regimen as to food, exercise, and rest. It would be interesting to detail the progress of this critical case; suffice it to say, however, that after the first four weeks her improvement became manifest to all; there was some evident return of flesh color; she had more appetite, and her menses had returned; she was stronger; said she did not feel "so tired;" was quicker in thought, speech, and action; and in one month more she began to play on the piano, at which she was a great proficient. But I do not feel confident of her safety; besides, Dr. Clarke tells me, that her sister has for years had more or less hysterical paraplegia, and I fear there is wanting a real foundation for any truly substantial health, although on auscultation the bellows sound is gone from the heart, and the cooing sound from the carotids; showing that the due balance of the blood circulation is reëstablished, the torpor is overcome, and the capillaries are fairly awakened to duty.

Bowels.

Dr. Treusseau, of the *Hotel Dieu*, Paris, recently published a paper in which he strongly urges the profession to the more frequent employment of "electro-therapeutics." He says, "I consider this *class of remedies* particularly indicated in many of those cases where there is reason to suspect *a general want of tone in the bowels*, as in the delicate, the sedentary, male or female, and in other cases, indeed, wherever there may be suspected a *want of tone* in the parietes of the abdomen, or muscular coat of the bowels themselves in consequence of great or long-continued distention; or, in short, where the constipation can be referred to an undue secretion of gas or flatus, which in itself, by causing habitual over-distention of the bowels, and

likewise of the hemorrhoidal vessels, diminishes their natural contractile power; also producing piles and other local weaknesses." (See Appendix E, F, G.)

Dr. W. Cummings, an English physician,* testifies that electric currents, in his hands, speedily brought about the cure of very many cases of *habitual constipation* which had resisted, in some instances, a great variety of treatments. Thus speak many other good authorities. Now, we reckon, that if habitual constipation can be uniformly broken up, and a more natural state brought about that is abiding, so that the bowels are more moist, both on the mucous and serous surfaces, that their calibre and place are more natural, that there is more natural peristaltic action of the intestines, that the muscles of the walls of the abdomen are toned up to symmetry, and this brought about by only such simple means, with little trouble and less expense, — is surely worthy of our attention and trial. It certainly has been my own experience during twenty years of general practice, that no such uniform, or, rather, frequent results, characterized with such permanency of relief for this most troublesome condition of many people, have ever attended any other sort of medication or regimen, either adopted by me or any one else. To be able to reëstablish the habitual, natural movements of such flabby bowels as have been irregular and "behind the time" for years, is an achievement any way and every where. True, there are persons who from carelessness neglect to be punctual at stool, or who by unwise habits of living, or from a morbid appetite for quack medicines, for tobacco, "lager bier," cheese and crackers, for smoked meats or dried herrings — of course, will be obstinately constipated, or alternately relaxed. But there are, besides, a multitude of others, who, notwithstanding careful living, punctual stool habits, and most strenuous efforts, perhaps, over and beyond a sedentary business, which, indeed, they must continue to follow, are still suffering from a general weakness of the whole abdomen, or a torpid state of the intestines themselves, but which is most usually ascribed to the liver! Now, for these, which, by the way, constitute an enormous class, there are no

* London Medical Gazette, vol. ix. p. 969.

other patients where this medication is more indicated than for such when correctly practised.

Intestinal atony is manifested as a *constipation*, arising from a want of peristaltic power of the contractile and muscular fibres of the intestines, or from a loss of tone or power of contraction in the muscles of the abdominal walls themselves. When both these states exist in the same case, *tympanitic distention* of the abdomen is very likely to be the most troublesome symptom. When neglected, it may become extreme, and threaten life by asphyxia from upward pressure. For all these states of atony I apply the sponge electrodes with Faradaic currents, first to the spine and then to the regions of the abdomen, never allowing the electrodes to rest more than fifteen to twenty seconds at any one place. The *labile* motion is my most favorite method here; using all the strength of current the patient can tolerably bear, and thus, as it were, *bathing the bowels with electricity without removing the electrodes*. I could here report any number of cases to illustrate this; but as the treatment is so similar, and yet influenced and varied in each case according to the general and special principles laid down in this work, that I forbear, simply adding, for example, that the *positive* electrode is usually placed upon the cervical or dorsal spine, while the *negative* is planted for a quarter or a half minute at a time over some portion of the colon, and then removed from place to place by being slid along without being taken off. At other times the *positive* pole is placed over the lumbar region or *under* the coccyx, while the negative pole is over the external abdominal ring. The current should run from the spine to the bowels, or be changed in direction from minute to minute; moreover, the electrode that is over the bowels, whether the positive or the negative, should be thus often alternately pressed very hard, so as to displace flatus from under it, and then again held more lightly, and then again moved along to a new position.

Dr. Robert Christison has employed galvanism in various *atonic* states of the abdominal viscera, and gives the following case * as an illustration of his views of " *extreme constipation in*

* Monthly Journal of Medical Science, Sept., 1858, p. 252.

elderly people:" "In the case about to be related, the patient had not had a stool for many days, which was his habit. On first seeing him there was no suffering. He seemed a fresh, vigorous, and active old gentleman. He took his food tolerably well; the pulse was natural; the tongue only a little furred. The abdomen is much distended, especially in both the iliac regions, where there are two large, prominent swellings projecting laterally much beyond the pelvic bones. There are, also, irregular swellings at different parts of the abdomen, especially in the track of the colon. Over some of these points percussion is quite dull; over others it is tympanitic.

"It was judged unsafe to give him active purgatives by the mouth at once, in case of the great gut being firmly obstructed with hardened fæces; therefore a turpentine injection was first properly administered to him by a student. The result was 'a prodigious discharge of fecal matter of all degrees of form and consistence.' Much of it was composed of very hard *scybalæ*. A dose of active cathartic was now administered after this forerunner, which brought away also a great mass of feculent matter. Active cathartics had frequently been repeated, but still the belly continued in the same state, presenting especially the singular enlargement and overlapping of the iliac regions.

"It was apparent that, owing to long continuous distention of the bowels with fæces and gases, *their muscular coats had lost their tone*, in some regions at least, and especially in the cœcum and the descending colon. It was then proposed to resort to electricity for relief from this sort of paralytic condition of the bowels; which suggestion was at once carried into effect. It is now more than twenty-five years since galvanism was recommended as a useful remedy in cases of obstinate constipation. We can easily see that it may be useful — and, too, upon what principles it acts. The earliest way or method of using it was by guiding the galvanic current in the direction *from* the mouth *to* the anus; and in this way it seems to have been most effectual and prompt, at least in some cases. But its action, to be effective in this manner, is rather disagreeable. But ulterior observations have shown that passing the cur-

rent in various directions through the abdomen itself, may be quite sufficient. This remedy seemed to be the more adapted to the state of our patient *after* the bowels had been thus cleared out, for it acted upon them with wonderful energy and success. After this current had been passed for some time, directed from the back to the bowels, as well as from side to side, he had, in an hour after, a copious evacuation. In three hours he had another, and next morning a third. Flatus was also discharged in abundance. The abdomen contracted and fell greatly, but still not completely. The pain of the galvanic action, however, had been so great that the patient begged to have a day's respite. On the second morning, however, this remedy was again applied, but more gently; and then again on the alternate mornings subsequently. He acquired by this means a daily discharge from his bowels, and sometimes two. The abdomen became more natural in size and form. Since those days he has had *a natural* evacuation every morning, and without aid, either from laxative or galvanism. He was dismissed, I should have said, after receiving fourteen treatments.

"This is a case," says Dr. Christison, "which gives an excellent illustration of the influence exerted by galvanic currents over the animal *functions.* It appears to me to hold out a probability that the same remedy may prove serviceable in restoring the tone of the intestinal muscles in other forms of troublesome chronic flatulent distention of the abdomen."

Dr. W. Cummings, of Edinburgh, gives the following graphic description of cases of his experience in the use of electro-magnetism in certain states of the bowels: "We are often consulted," he says, "by patients who, at the first glance, convey the impression that *they are imperfectly nourished.* They have an emaciated appearance. In detailing their symptoms, they lay great stress on a feeling of 'all gone,' or, rather, a faintness at the epigastrium; they complain of exhaustion there. They generally next direct our attention to a more or less *fixed pain*, either in the left hypochondriac or iliac region, sometimes both, but more frequently in the latter—a pain from which they are rarely exempt, and which is sometimes very severe and

acute, though more often annoying and irritating. If they have ever been induced to apply a mustard poultice to the seat of pain, they dwell on the relief, great, though temporary, they have experienced from it. The stomach, in most of the cases I have seen, has not been irritable; it commonly retains and digests the food; but pain is frequently felt in the course of the colon, in a period varying from an hour to two hours after eating. The bowels are at one time constipated, at another lax, in the same person. Some are uniformly costive, others more frequently loose; but in all (*and this is the characteristic mark of the disease*) there is a peculiar membranous, fibrinous, or jelly-like matter discharged from the bowels. In some cases, it is stringy; in others, tape-like in its form; in others, again, it is in small masses, resembling fat or stiff jelly; while, in the milder cases, it is more diffluent and gelatinous."

That this disease has, from want of proper and actual examination of the intestinal *evacuations*, frequently eluded observation, I know too well from my own experience, and that it has consequently been maltreated does not admit of doubt. The last thing the patient will mention, (if indeed he mention it at all,) is the characteristic discharge. When the doctor directs his or her attention to it, they will hesitatingly admit that they may possibly have remarked it; nay, even when they are informed that it appears with every stool, they will often fail to discover it; and hence no practitioner should rest satisfied, when he has reason, from other indications, to suspect this affection, till he has *himself* examined the fæces most carefully, particularly while *separating* the fluid from the solid matter. In the former, as they are being poured off, he will rarely fail to discover flakes, or shreds, or even small masses; these, if discovered, will lead, at future opportunities, to the detection of larger and more unmistakable portions of this abnormal secretion. To take the *report* of the appearances from the patient, is, in too many instances, the surest way to deceive both him and yourself. In addition to this, there is not unfrequently (but not always) a discharge of blood from the bowels, and that, too, *where no hemorrhoids can be detected.* Almost uni-

formly, *there is excruciating pain during evacuation, and always a feeling of exhaustion for some time after.* In most of the patients, there is a peculiar expression of countenance, so striking, that one who has understandingly seen many such cases can with tolerable certainty tell, without more minute examination, what the nature of the complaint is. It is an expression of anxiety and irritability, quite different, however, from that which usually marks organic disease. You must not conclude, however, as is too often the case, that your patient is laboring under an *incurable* malady. Scarcely less characteristic of the disease than any of the preceding symptoms is the *state of the mind.* In all there is more or less nervousness, greatly increased towards night, sleeplessness, or dreams of an unpleasant nature, which is almost invariable. One lady was troubled often with spectral illusions.

Professor Simpson has observed that in most of these cases that have come under his notice, there is *a deficiency of memory in regard to words.* The patient knows what he wishes to express, and is loquacious, but cannot find the desired expression at the moment. In my own experience, I have not observed this so frequently; and certainly in very many cases it is wanting; this is therefore not invariable. When the affection has been of long duration, (and too frequently this is the case before we are consulted,) the *mental irritability* is very great, and perhaps confirmed; and what is more painful still, the patient's feelings and views are quite perverted and distorted. It is unnecessary to add, that *they are miserable in themselves*, and where the nature of the affection is unknown to, and due allowance not made by, their companions and friends, *they are truly a cause of misery to others.* They are quite sensible that they are not what they formerly were; that they are changed in temper and condition for the *worse;* they feel, moreover, that they have little control over their mental state, and are apt to fall into a condition of great depression and despondency. If I were to express their internal feeling in few words, I would say that "they have a mixture of irritability and despondency, relieved, from time to time, by happier

53

feelings; but that those latter are of comparatively short duration."

This state of the bowels is vastly more common in the female than in the male sex, though by no means uncommon in the latter; and in the former it is very often *accompanied* by dismenorrhœa, and occasionally, too, by the membranous form of that affection.

The primary, and I believe indispensable point for cure is, first, a total, or almost "*total abstinence from purgative medicines*." With this view, I was till lately in the habit of relieving the bowels every third or fourth day by *enemata* of simple warm water, or with the addition of a table spoonful of salt and molasses, or oil, and perhaps every ten or twelve days a dose of laxative by the mouth. These means, simple though they be, *actually do mischief;* and therefore it was desirable to discover a mode of effecting the object, without the disadvantage of its being, at the same time, an irritant and debilitant.

External counter-irritation is the second point; and this, from shampooing, or a mustard poultice, or both, every night or second night, gives considerable but only temporary relief, which, however, was always most grateful to the patient. But in very many instances it failed utterly, and where it did benefit the relief was usually transient.

"Circumstances which I need not at present detail," says Dr. Cummings, "led me to surmise that electro-galvanism would accomplish both those indications of treatment, viz., counter-irritative and laxative, *without the disadvantages* to the patient with which other means are chargeable. The results of its use, in a considerable number of cases of this *intestine disease*, warrant me, I think, in affirming *that electricity is competent of itself to the cure of almost every such case*, and that if aided by a *unique* internal medicine, which I shall refer to presently, it will *cure* both *certainly* and *speedily*.

"In the first place I find it acts as an aperient, seemingly by its action on the intestinal muscular coat, as well as the secretions of the mucous membrane of the bowels. *In every case in which I have used it, this has been the effect;* and if it had no

other consequence beyond this, the advantage from it is *prodigious;* for, as in a multitude of instances, this ultimate affection has been traced to the use or abuse of laxative medicines taken as a cure; hence, since during the treatment of this affection, even the mildest aperients irritate the mucous membrane, and so far aggravate (temporarily) the disease, therefore the evacuation of the bowels, by any other means that do not irritate nor yet exhaust, but, on the contrary, can invigorate, is obviously of vast consequence. But the electro-magnetic currents do more than this; for, secondly, it induces such a changed state of the bowels as prevents the further formation of this peculiar secretion; that is, it restores the bowels to a more healthy condition. I purposely avoid using expressions which might involve a theory as to its mode of action, and do not profess to tell how this result takes place. *The fact itself is undeniable.* Thirdly, electricity supersedes all counter-irritation. The pain in the side, for the removal of which the counter-irritant was employed, is relieved by an application of the galvanism for at least twenty-four hours; in many cases for a much longer period; but as the agent is applied once a day, where no contra-indicating cause exists, till the disease is removed, it may be said that *the pain is abolished* at the same time.

"Electricity can of itself effect a cure; but I have generally combined it with the internal exhibition of *tar*, and have thus effected cures in a much shorter time than by either of these means singly. For some time I was in the habit of giving internally the nitrate of silver, or cod liver oil, as circumstances directed; but latterly, I have confined myself simply to the simultaneous administration of *electricity* and *tar* for these cases, as suggested first, I believe, by Dr. Simpson, and have found that it, of all internal means for these cases, is by far the most prompt and permanently effectual. This relieves the feeling of exhaustion at the epigastrium, imparts an agreeable warmth, promotes appetite and digestion; but the tar, by itself, is long in effecting a cure, even in slight cases, in all the trials I have made of it. The plan I have hitherto adopted has been to give the tar in the form of pill or capsule, thrice a day, while the electro-

galvanism is repeated for a quarter of an hour, daily, the intensity being increased from time to time. Steady perseverance for a season is requisite. With this method, according to my experience, the case must be obdurate indeed that will resist a cure.

"One remarkable fact connected with the treatment by electro-magnetism is, that it detects the very portion of the bowels where the greatest amount of irritation exists — a knowledge which manual pressure often fails to elicit; for it is a singular truth, that where the instrument is in action, extreme tenderness is complained of in more than one well-defined spot or tract, of which usually the patients were not previously aware, and that, perhaps, quite distant from the regions to which the attention of the doctor is directed, as the seat of pain. It is extremely interesting to observe how this tenderness, after a time, from the continued use of electro-magnetism or galvanism, diminishes, until a mere point is fixed upon, as its seat, and how this also is removed; after which the disease may be said to be actually *extinguished*. Yet I have seen reason to persevere, at more distant intervals, in the application of this agent, for the sake of confirming the recovery by strengthening the nervous system, and conducing to the self-regulation of the bowels."

The foregoing testimony of Dr. Cummings on this point is extremely valuable; indeed, I know of none more so. But I am inclined to think that the harassing pains attending these cases are, in part at least, seated in the parietes of the abdomen — a muscular hyperæsthesia that, though a part of the affection, should be correctly designated. As the abdominal viscera are always a little slower to respond to the electric influence than are voluntary muscles, so, when treating here, and the *positive* electrode is upon some part of the spine, while the negative is upon the bowels, the latter must be *compressed and retained for some appreciable time in a given spot* in order to make any real and abiding impression upon the underlying bowel. This is all-important, even while the electrode that is on the back is being moved up or down, as also when both electrodes are applied and embedded in the flanks of the abdomen itself.

Cholera.

In 1854, Dr. C. Meinig called the attention of the medical world to the great value of the primary current of galvanism in the treatment of *choleraic diarrhœa.* Where the symptoms are violent, bowel discharges are attended with pains, cramps, and spasms, or movements and *borborygmus* in the bowels, with swashy diarrhœa, vomiting, cold sweating, cramping sensation in the legs, &c. The method he pursued in such cases is thus given:—

The *positive* electrode of his portable (and powerful) compound galvanic battery was first applied to the *spine*, between the shoulders; the *negative* pole being placed on the abdominal region, and occasionally moved higher up or lower down, according to the varying seat of the pains, and coldness in the bowels. The good effect of the current was uniformly perceived at once, in a feeling of warmth and tone in the bowels, the pains uniformly and entirely disappearing in about half an hour; both the diarrhœa and vomiting subsided only gradually, in the course of from two to five hours, when slight weakness was left, the urine reappearing shortly after the application of electricity, probably through the action of the current on the urinary organs. He says, "I have witnessed these results in eight cases, one of them finally being in my own person; in which case, to attest my confidence, I purposely abstained from employing any other remedy whatever. It was here often found necessary to communicate the current to the abdomen by means of a metallic plate electrode, of sufficient size to cover the whole abdominal region, as the patients complained that the warmth was limited to the exact position of the previously used small disk, and did not sufficiently pervade the whole abdomen. In one or two cases, I observed the remarkable circumstance, that while the diarrhœa lasted, the pricking sensation at the negative pole was almost nil; whereas, after the disappearance of the complaint, the skin was blistered, in about a quarter of an hour, by the power of the current. I certainly

look upon these observations as of sufficient importance, at the present juncture, to induce physicians to test their validity, the more so as it can be done without great trouble, and without precluding the use of other remedies, and as the successful results here stated may very easily be accounted for. Whatever may be the difference of opinion as to the *cause* of cholera, and the nature of cholera or its symptoms, and consequent treatment, two points will be conceded by most thinking men.

"1. That it is of the utmost importance to keep up the power of the central, as well as of the digestive system, so that, if diarrhœa there must be, the other functions are disturbed as little as possible.

"2. That in this disease, that remedy is the most preferable and certain of effect, which is the most *directly* applicable, and the most independent of the disturbed digestive functions.

"In sending a continuous mild stream of electricity (here using no interrupted or shock current) from the spine to the abdomen, I *vitalize* — keep up the power of — the whole central and digestive systems, and by keeping in action all functions, I prevent the diarrhœa from taking a virulent and passive character. I do this instantly, and independently of digestive functions, strongly or mildly, continuously or intermittingly, at option. All the effects purporting to be produced by the means generally employed, are thus produced much more perfectly and instantaneously by this simple application. However, volumes of reasoning will never supply the test of experience. Therefore let electricity be fairly tried, and stand upon its own merits.

"With regard to cases of collapse, I cannot speak from experience, never having witnessed such a case. It is, however, a fact witnessed by me dozens of times, and very easily demonstrated, that *spasms* and *cramps* of the *ordinary* description cease in a few minutes under the influence of strong primary *continuous* (not shock) currents passed along down the spine and the contracted limbs; and with regard to the maintenance of irritation in any given part of the body, it will be obvious to every one that no other means at command can bear the most distant comparison with electricity, for such purpose.

"In cases of collapse, I would fix one disk on the spine, the other on the abdomen, as above stated; and, in addition, I would send the strong continuous current from a galvanic battery first along down the spine, and then from the spine along the cramped or contracted parts, also through the liver, stomach, and bowels; a few shocks to be used only where it was necessary, and *but momentarily*, to stir up the whole system — in fact, simply to keep up life." The key to understand the relative bearing of the foregoing treatments is found in those words where Dr. Meinig says, "The skin was blistered in fifteen minutes by the power of the current employed;" that is, he employed a very powerful primary current in these extreme cases, and produced such uniform good results.

From the theory of cholera as published by Sir James Murray, in the London Medical and Surgical Journal, in 1832, and since amply confirmed in many parts of the world, it is to be concluded that the judicious use of electro-magnetic or galvanic passes, patiently persevered in, through the *respiratory and spinal nerves* is one of the most essential adjuvants that can be employed *during collapse*, or that state of *passive electric abstraction* which ought to be treated much like suspended animation.

An article by Dr. J. C. Atkinson, in the Lancet of 1848, p. 504, says, "I am desirous at the present moment of calling the attention of scientific readers to a very interesting phenomenon, more or less present in the *collapse stage* of cholera, which seems to have hitherto escaped the observation of medical men, viz., *animal electricity*, or phosphorescence of the human body. My attention was first attracted to the subject during the former visitation of that fearful disease in the metropolis. It was indeed singular to notice the visible quantity of electric fluid which continually discharged itself on the approach of any conducting body to the surface of the skin of a patient laboring under the *collapse stage*, more particularly if the patient had been previously enveloped in blankets. Streams of electricity, many of them averaging one inch and a half in length, could be readily educted by the knuckle of the hand, when directed to any part of the body; and these appeared, in color, effect,

crackling noise, and luminous character, similar to that which we are all accustomed to observe when touching a charged Leyden jar. I may remark the coincidence that, simultaneously with the heat of the body passing off, the electricity was evolved; and I am therefore led to ask the question, Are not heat, electric and galvanic fluids, one and the same thing? Does not the fact of the passing off of both imponderable substances at one and the same time strengthen this conclusion?

"Again, are not the whole of what we call *vital phenomena* produced by certain modifications of the electro-galvanic-magnetic matter and motions? And do we not find that these vital phenomena are continuously affected by the relative state of the surrounding electric medium? To what can we attribute the present fluctuating condition of the barometer, if not to it?"

We know what wonderful decomposing action galvanism had on alkalies, under the hands of the illustrious Humphry Davy; but we do not know, nor have we any conception, in the present state of knowledge, of the decomposing action of the electric matter of the atmospheric air, in its various conditions, on the fluids generally of the animal body. Chemistry has failed in pointing out any other, or ponderable material as the exciting cause of epidemic diseases.

In the treatment of cholera, all are agreed that non-conducting substances on the surface of the skin aid essentially in the cure; and during the disturbed state of the atmosphere, for the purpose of retaining the electricity continually eliminating in the system, we are told to wear woollen bandages, flannel, and gutta percha soles, so as to insulate as much as possible the body, to prevent the heat and the electric fluid from passing off. (See Appendix F, G Note 3.)

Breast-Milk.

The lacteal secretion is a veritable nervo-chemical phenomenon; yet the good effects of electricity on the mammary gland, in case there is very deficient secretion, suppressed or poor secretion of milk, and in other abnormal states of the milk-giving breast, (except the inflammatory,) show it to be not so

much a chemical as a physiological action through the nerves and vessels that determine this secretion. The primary galvanic current, I find, is decidedly the best for this purpose; and this should be most carefully managed, and of the mild, or at least agreeable strength. The positive electrode should be placed *above* the breast, or in the axilla, while the other is on the breast, and so that the current will be as even as possible.

M. Becquerel reports, as an example of its repeated success in his hands, the case of a lady twenty-seven years of age, who had the secretion in her left breast almost entirely dried up, and in the right it was greatly diminished. This was produced by untoward circumstances soon after her accouchement. He employed in this case the induced currents of electro-magnetism, but of the most rapid vibrations, and of moderate intensity, — using large, soft, and moist sponge electrodes, placed successively on different points of the surface of the breast, so that the current might pass through and through, traversing it in all directions. Three *seances* of fifteen minutes each were held, and at the end of the third day the flow of milk was abundant. Since that time, and as long as she nursed the child, there was a good and sufficient flow for it.

For "*sore nipples*," use the Humboldt battery. I have succeeded with this where all other means had been exhausted in vain. But I have observed, and hold it as a *rule*, that those cases of sore nipples which occur in enfeebled women are *thus cured* more readily than when they occur in the fleshy and robust. My method is to apply the silver pad over the sore nipple, while the zinc pad is placed above the breast, — say on the sound surface of the pectoral muscle, — and if it irritates there, (i. e., under the zinc plate,) then remove it to the right or left, on sound skin, but retain the silver, whenever applied, always over the nipple. A great help in the cure of sore nipples, in these two classes of patients, is a saturated solution of borax and kino. For example, put into an ounce vial one drachm of finely powdered borax and two drachms of powdered kino or catechu, and fill up with warm water, if the woman is robust; but if very feeble, fill up the vial rather with brandy, or New England rum, but not with alcohol. (See Appendix G.)

Dropsy.

In very many instances, that is, where the œdema, or the accumulation of fluid in the cavities, is not the result of fatal organic disease, both Galvanic and Faradaic currents have proved highly serviceable — in some instances independently, in others as auxiliary. This is rational. We know that the bright arterial blood flows out through the moss-like fringe of minutest arteries into the capillaries, and so on again into the anastomosing fringe of veins in its return back to the heart and lungs. Now, in that intricate pass from the ultimate twigs of arteries into the ultimate twigs of veins, the blood appears to yield a portion of its moisture by the process of exudation and imbibition, by which the various tissues are lubricated and *nourished.* But in some mysterious and intricate instances, either from the blood being more watery, or poor in iron and salts, or from some change in the state of the tissues, this exuded or imbibed fluid, *with its debris*, does not get back into the veins, but rather accumulates in the cellular tissue, and this is termed *œdema.* On the principles of endosmosis and exosmosis, it is well understood, and, moreover, we can comprehend its relation to the naturally vitalized electro-nervous battery of the organism.

In cases of anasarca, particularly of the lower extremities, the smart primary or secondary currents, applied through small, approximating, and as ceaselessly moving electrodes, will usually produce muscle fibre and capillary contractions, which will be followed by warmth and strength, and consequently there will be a disappearance of the dropsical effusion. This is facilitated by a daily wash in warm water, and then the sudden shock produced by a splash of cold water for one moment.

Hydrocele. — My experience here has been limited; but the few cases I have had occasion to treat by electro-therapeutics, have resulted favorably. One case was managed by applying the sponge electrodes, with some pressure, on the surface of the scrotum, using full bearable currents of electro-magnetism, and repeating it every day for one week, when the absorption was

complete, and the case remains well. In two other cases I employed also the electro-puncture with the primary galvanic current. One of these was an old and ugly case — Mr. Kittredge, of Berkshire, aged forty-five, who presented in May last; a very large hydrocele of the left side, that had been repeatedly tapped and injected for radical cure; and although he suffered inflammation, yet the hydrocele was large and painful. It was fully the size of an infant's head, and appeared a formidable case.

This patient took the operating chair, which was swung to a very reclining posture, so that, indeed, his hips were higher than his feet or head; knees raised and widely separated. I then carefully plunged into either side of the scrotal sack two gold electro-puncture needles, taking care not to wound the testicle, — which, however, is usually well back out of the way, — and thus applied the constant current of galvanism from five to fifteen elements of Daniell's battery, reversing the current every minute, and continuing the *seance* for fifteen minutes. As does goitre, so did it visibly diminish in size during these fifteen or twenty minutes. This was repeated every other day, together with some induction currents to the surface of the scrotum to finish off with, for three *seances* more, at the end of which there was no water in the sac, but the left testicle hung lower than the right, and was still somewhat tender and painful. In a fortnight more, this soreness removed. It is now some eight months since he came to see me, and I learn that he remains perfectly well.

The other case, although not so apparently unfavorable at the beginning, was similarly and as thoroughly treated, but it is as yet but partially cured. In this case, however, there is evidently but little nervous power in the parts, for the penis is without erection, and when the positive electrode is placed just back of the ischium and the other is pressed at the root of the penis, there is but the slightest sensation from the strongest electro-magnetic current, showing that the *pudic* nerve is all but paralyzed. (See Appendix E, F, G.)

For glandular enlargements, as well as for lymphatic tumors, M. Boulu has, since 1853, been especially using electricity, and

that, he says, with varied success. On the whole, he finds that fine platinum needles for electrodes, plunged deeply into the mass of the tumor, and so leading the current through it, work the best of all. He quotes a large list of cases and experiences in this line, and his final opinion is, "that, for these cases, the current is both chemical and exciting to the circulation and absorbents, also producing a capability and tendency to contractility in the vessels and tissues about the affected parts, that not a little, aid to wither the tumor."

Cancer and Tubercle.

Neither of these affections is directly eliminated from the system by electricity or any other medication. In the former disease, however, induction (secondary) currents have sometimes afforded most charming temporary relief. In the latter, electric currents can be so employed as to arouse some more abiding vital action in the weakened muscles of the chest, so as to make respiration deeper and stronger, and thus vitalizing the lungs and other portions of the body, without stimulating the tubercular mass very much. I have not a question that tubercle may be seized upon by the forces of nature through the absorbents, and thus often rendered latent, or perhaps in some instances removed. I have seen cases recover under the electric treatment, and endure labor and exposure afterwards, who were pronounced by able physicians to be marked with tubercular deposits. (If resorted to, see Appendix F, G.)

Tubercle and cancer, it is to be borne in mind, are very different diseases; the former possesses no fibrous stroma, but is simply infiltrated among the elements of various organs, the vascularity of which it tends to destroy. A cancerous tumor increases by actual growth, cell by cell; but tubercle does not, for it is rather deposited, accumulated, or *left;* the cancer is vascular, the tubercle is not; in the former, cells are organized which have the power of redevelopment; in the latter, reproductive cells, or self-propagating processes, are never produced. In cancers, the morbid matter circulating in the blood — whatever

that may be — has an *election* for the cancerous part. In tubercles, successive exudations or deposits are made, which, by accumulation, augment the volume or amount of space occupied by the repeated deposits.

Tumors of tubercular degeneration in glands, as about the neck, are doubtful cases, and should be approached with the currents in the most cautious way. These are, after all, not a little inviting for this treatment, seeing that electricity produces, when properly employed, *an increase of life* in the tissues, and, in a word, tends to replace a normal state where it is abnormal; and why may it not *aid* to wash away the deposit which is always left in a debilitated spot?

Consumption.

The first stages of tubercular phthisis is generally stated to be that in which the *physical signs* indicate a deposit in the lungs. But, able men in this speciality say, we must evidently go farther back; there is unmistakable and undeniable evidence by earlier symptoms, than there are stethescopic signs — long before the able and most skilful observer can detect the sound which indicates the least shade, or degree, of solidification of the lungs, — *there is an antecedent state* of disordered health, acting as the causative agent, that originates the predisposition or tendency to the deposit of tubercle in the tissues, and elaborates or prepares the material in the system from which only tubercle is formed. *To this very point I would entreat an earnest and careful attention.* Here is the very "point of departure." It is not only the key to the very meaning of the name of this disease, but it is the only truly, i. e., uniformly, hopeful period for treatment.

To sum up our opinion, then, much in the concise words of others, (but judging from our own most careful observation and experience, by questioning and examining some hundreds of such patients, and by the frankly avowed opinions verbally expressed by those who have vastly greater opportunities in this speciality of thoracic diseases,) we feel no hesitation in saying

that the actual first set of symptoms of tubercular disease consists simply in the "*wasting of flesh, if this is attended with a lower scale of health and strength.*" Now, this loss of muscle plumpness, as well as juices and fat, is first noticed, according to several good authorities, in three principal places: the first region of flesh *consuming* is the face; second, the hands; third, over the sacral bones. The sacral region, where it first gives out, is lame and sore, and looks poor. The hands look poor and "scrawny," the muscles of the arms and legs are soft and flabby. If the face shows it first, the eyes stare; the brow, temples, and scalp look lean; the muscular tissues of all the limbs soon waste, and the *pectoral muscles*, as also all the chest muscles, waste away, and then the breathing is already become imperfect and weak. This *diminished respiration* is soon attended with cough; then there are pains about the thorax. The patient next is sensible of something wrong, and is conscious of a sense of general debility. The fact is, nutrition is lost; the vital powers are flagging, for the wasting of the organism, in spite of eating, is more rapid than the repair. Then comes a stage of spirit depression; not the *cause* of consumption, but caused by the already deficient vitality, and all the more helping on the catastrophe; for it is a law of our being, that where nerve structure is not itself nourished, it, too, will fail in its work, just as surely as muscle fibre fails of power from the same cause. *With diminished nervous power we all know how the "emotions" begin to master the former intellectual vigor*, and there is no natural resistance made to any accidental debilitating attack, because of an *absent vital energy.* If appetite flags, it is from the absence of the demands of the general vital element in the body and brain; while the *capacity* for digestion still remains unimpaired. This, however, is not always understood, but it is usually blamed, and hence incorrectly treated. Now, I wish to be distinctly understood to say, to every intelligent practitioner, *that all this may occur*, and in thousands of cases does occur, *and yet may be cured in almost every instance.*

In these more *early marks* of an insidious disease, whose fatal end, though not so speedy, is yet even more inexorable than

small pox itself, — in this *very early*, and yet, perhaps, full late enough stage of what may as yet be termed "*no disease*," where there is perhaps merely unusual pallor of the countenance, and of the general surface, as also of the mucous membrane of the lips, mouth, and fauces, with perchance here and there some already injected patches in the pharynx, and, at the same time, there are notably *diminished* chest movements, (for the muscles of the thorax are probably already relaxed, if not wasted, though there is but little or no alarm,) the patient most usually being conscious of only a sense of weakness, and a dryness in the air passages which induces a cough, and this is referred to the fauces, pharynx, and upper part of the larynx alone, being most annoying in the early morning, or on changes of weather, or of temperature — this is the stage, and these are the cases, I say, that I have so often met with, which, after having resisted the sedatives, nauseants, and expectorants of orthodox prescriptions, Peruvian sirups and lozenges — after all, *yield* to the methodical application of labile, but gentle currents of Galvanism or Faradaism, directed more especially to the upper part of the spine, *and to the enfeebled chest muscles*, daily or tri-weekly repeated, and that in connection with the very same regimen, and such rational prescriptions as before had not proved quite sufficient to gain the day, being directed to but the internal portion of the malady, while this other portion of it remained unreached, and, perhaps, unheeded. That the general tonic, and perhaps the oil, phosphates, or chalybeate plan of treatment, is likewise needed for these "*not sick*" persons, can scarcely be doubted. This all applies, however, *to this first stage* of consumption, or, if you please, rather to such marks of a candidate for it; nevertheless, if *here met, and thus managed*, I contend that death, even from uncomplicated pulmonary consumption, occurring, as it does, mostly among the youthful and those in the very prime of life, might become as notably rare, as it is now appallingly frequent. I could show this by detailing numerous and almost uniformly successful cases, but I do not see that it could any way illustrate the *modus operandi*. (See Appendix F, G.)

CHAPTER X.

ELECTRICITY IN SURGERY.

At the University College Hospital,* Dr. Marshall has made some very interesting trials as to the efficacy of the electric current in *benumbing* parts ready to be submitted to surgical operations by the knife, the idea involved in these trials being of course derived from its conditional advantages in "tooth-drawing." As many as nine operations, requiring incisions of various kinds, have been thus performed. Excepting where the current employed seemed to be too strong, the pain of the incisions appeared, on the whole, to have been so modified as to be somewhat more endurable than is usually the case. In one instance — that of the adipose tumor — the cuts were very slightly felt. There was *no* instance, however, of complete anæsthesia; and it would be premature to flatter ourselves that, in regard to the effects of electricity in *cutting operations*, any thing more than a modifying influence had yet been certainly obtained. Electricity, in any fair sense, is *no way* paralyzing.

Dr. John Snow concludes that the sensibility of the body may be "*couched*," suspended, or destroyed in two ways. First, it may be accomplished by the direct effect of some temporarily *benumbing* agent on the *extremities of the nerve* ramifications of the part. Secondly, by the effect of the agent on the *centres of intelligence;* i. e., by the destruction of consciousness. This may be illustrated by contrasting the probably different effects of amylene and ether. The former acts mainly on the periphery twigs of the sensory nerves. *Ether*, on the other hand, *suspends sensibility in proportion as it destroys consciousness for the time. But electric currents cannot produce complete anæsthesia at our will, either uniformly or safely.*

* Lancet, Sept. 18, 1858, p. 297.

Nervous Affections of the Eye.

Where the patient "*sees double*" *persistently*, and in fact, as a general *rule*, in all cases of supposed head affection, where the patient sees double, or sees only half of an object at a time, this is to be considered as a very bad symptom, and death may be feared or expected from effusion into the substance of the brain, sooner or later. True, we do meet with many cases in which some shade of this abnormal state of vision is *temporary*, and is then only indicative of some functional derangement; but mark, where it is of longer standing, or other evidence of cerebral mischief impends, it is always a suspicious symptom, and should be closely watched. (See p. 231, and App. D, 3.)

The state of the *iris*, in diagnosticating "cerebral lesions," is of importance. We should perhaps look first to the mental condition, but next to the state of the pupils of the eyes. If the eye itself is diseased, the dilated pupil indicates more or less pressure on the retina by some cause within the globe, such as turgid *choroid*. But when the eye is healthy, and the brain has received some supposed injury, we usually find a *dilated* pupil as a sign of some grave pressure or injury to the optic nerves within the skull, or of the ganglia in which they terminate. The *contracted* pupil, on the contrary, indicates an irritability, or inflammatory state of the brain, — an exalted excitement of the natural function, — but not an obliteration of it. "Sometimes," says M. Solly, "we may see, as in the case of injury of the brain, dilatation of one pupil, and contraction of the other; when this is the case, you will find the most severe injury of the brain on the same side with the dilated pupil."

A seamstress came under my care for a blindness that came on very suddenly in one eye, after sewing on black satin by gas light. The pupil was dilated and *immovable;* she was totally unable to distinguish even light from darkness. The case appearing to be one of idiopathic palsy of the iris, I therefore proceeded at once to apply electro-magnetism, directed to the opposite sides of the naked cornea, by very small ivory and

sponge-tipped electrodes, conveying a very weak, but rapidly interrupted current. Three applications restored the sight, and tonic medicines, with rest, confirmed the rėstoration. There is a nervous affection of the eye, termed *musca volitantes*, which is an aberration of the sense of sight that transmits the image of some of a multitude of imaginary objects. This may be simply symptomatic of *fatigued* nerves, or it may be idiopathic, and connected with the state of the brain. I will concisely say that where the "black spots" or "shining sights" have a circular or *perpendicular movement*, particularly if at winking, the affection is then probably symptomatic, requiring rest and very gentle localized Faradaization by *team-electrodes*, or a bathing of the closed eyes and surroundings with the moist sponge *positive* electrode, while the other is on the back of the neck. If the black spots, &c., are *stationary*, they probably are idiopathic, and should not be so disturbed.

A young gentleman, a student at Cambridge, came to me with blindness of the right eye, which he said was a sudden occurrence, and that, probably, from too close study by candle light. He could still see *very distant* objects quite distinctly; but he could not make out objects near by if his well eye (which was also dim) was closed. The pupil was largely dilated, the iris being drawn closely to the ciliary ligament, and it was unmoved by the approach of a strong light. He had been under the care of one of the most distinguished oculists for the six months previous, during which he had been leeched, blistered, and mercurialized, without any benefit. A weak current of induction was first tried for a few times, directed upon the two sides of the globe of the eye, over and through the closed eyelids. This was without effect. I then made gentle touches to the sides of the cornea and sclerotica, and at the close of each seance applied by a camel's hair brush a weak solution of sulphate of copper around the sides of the cornea, where the electrode had just touched. After ten such sittings, performed every other day, his eyes quite recovered, now bearing close study, and yet remaining strong.

Ptosis, or "falling of the upper eyelid," often arises from

an *atonic* or paralytic state of the *levator palpebræ superioris*, owing to some alteration in the nerve that supplies it; or it may arise, on the other hand, from a spasmodic action of the *orbicularis palpebrarum*. When this affection occurs from true local palsy, i. e., showing that the third pair of nerves is palsied, then there is usually "*squinting*" with the ptosis. In this case, we should bear in mind that, usually, electricity in any form is not only useless, but hazardous. In the former, Faradaization of the *palpebra superioris* muscles and its nerve trunk will cure it. (See Appendix D, Note 3.)

When only the motor portion of the fifth pair of nerves is palsied, then there is usually found, moreover, a slight loss of sensibility in the parts of the face supplied by the *tri-facial, and the motions of the jaws*, on the affected side, are impaired. Mastication is therefore difficult on that side, owing to the palsy of the *masseter* and *temporal* muscles. This may occur alone; but more usually there is also loss of sensibility and palsy of the *portio dura* and the face muscles of that same side.

I wish to remark here, that we must be reminded that the *portio dura* and the *portio molis* of the seventh pair (the facial and the auditory) are placed so immediately together within the cranium that it is scarcely possible for the one to be *there* affected without the other. Hence I make it a *rule* to inquire *if there is deafness*. This, when wanting, I consider, is a strong diagnostic sign that the lesion is external to the cranium.

Artificial Pupil.—M. Tavignot,* after enumerating various circumstances which may render the results of the ordinary operation for *artificial pupil* unsatisfactory, states that he had been for some time thinking of employing the galvanic cautery for this operation, and has actually succeeded in employing it. Its chief advantages, he claims, are, that the new pupil may by it be established instantly, and without hemorrhage, and that its dimensions and shape can be exactly determined. Being a more simple manœuvre than the tearing through the iris, it is less likely to be followed by inflammation. Moreover, the aperture can as easily be made in the cases in which false mem-

* Moniteur des Hospitaux, 1858, No. 119.

branes line the posterior surface of the iris, or obstruct its central portion. Thus far, he only deems this procedure applicable to those who have already undergone the operation for cataract; as, in case the lens being present, its opacity would be induced during the application of the cautery. He prefers for this purpose the compound Bunsen's battery. Having made an incision at the external circumference of the cornea, he passes in the cauterizing needle, directing its platinum ring to the point he wishes to influence, taking care not to cauterize the edges of the external wound, nor the posterior surface of the cornea; and, when fairly adjusted, contact is made, and retained, and broken, as he judges best at the moment.

Nervous Affections of the Ear.

According to Dr. Toynber, of St. James's Dispensary, the most prevalent *local* cause of deafness in the ear is a chronic low inflammation of the mucous membrane which lines the tympanitic cavity; and he thinks by far the greater majority of cases commonly *called* "nervous deafness" ought more properly to be attributed to this cause. We should be reminded of the *three stages* of this condition (while contemplating aid by galvanism) as being,—

First. Where the membrane retains its natural delicacy of structure, though its blood vessels are considerably enlarged, blood is seen effused into its substance, or perhaps more frequently at its attached surface.

Second. Where the pathological condition shows the membrane to be very thick, and often flocculent. In this state, the tympanic plexus of nerves becomes involved and concealed; the base and *crura* of the *stapes* are frequently completely embedded in it, while the *fenestra rotunda* appears only like a little depression in the swollen membrane.

Third. Where by far the most frequent and peculiar characteristic of this second stage of the disease, is *the formation of membranous bands between various parts of the tympanic cavity.* These bands are at times so numerous as to occupy

nearly the entire cavity; sometimes they connect the inner surface of the *membrana tympani* to the internal wall of the tympanum and the sheath of the *tensor tympani* muscle. The place where these bands and adhesions are more frequently found by post mortem examinations is between the *crura* of the *stapes* and the adjoining walls of the tympanic cavity; at least, this was the case in twenty-four instances out of one hundred and twenty dissections. These bands of adhesion sometimes are found to contain extravasated blood, or scrofulous matter.

In the third stage of *inflammation* of the ear membrane, it becomes ulcerated; the *membrana tympani* is then destroyed, and the *tensor tympani* muscle is atrophied, (wasted.) The *ossicula auditus* become diseased, and are ultimately discharged from the ear; the disease often extending itself, now to the tympanic walls, and then affecting also the brain and other important organs.

Dr. Kramer, of Berlin, says, in regard to the "*appearance*" of the *membrana tympani* in health and in disease, that, "by the most careful ocular inspection of well nigh four thousand cases of ear diseases, which was repeated on some of these many times, I have arrived at the most undoubting conviction, that the '*healthy*' *membrana tympani* is entirely colorless, shining, and diaphanous, having a well-marked concavity externally; and that, under the influence of the inflation of the tympanum, while the mouth and nostrils are closed, it is raised only into two round, longish swellings near the *malleus*, whence we may conclude that it is in a state of expansion.

"The '*diseased*' membrane, on the other hand, I have always found either inflamed, and then red as a lobster, or reddened, thickened, degenerated, swollen, or indurated; or, the inflammation having ceased, some of the numerous consequent changes of organization have been detectable; all these cases likewise excluding the idea of *relaxation* from or after inflammation, as its sequel." Dr. Kramer, it appears, arrives at the following conclusions:—

1. "The *magneto-electric* or *electro-magnetic* currents act decidedly as an *excitant* on the organ of hearing.

2. "This action is strongest when the magneto-electric current is conveyed *from* the mouth of the Eustachian tube *to* the external auditory passage of the same ear, instead of from one auditory passage to the other." Thus it should be employed in case of affections of the auditory nerve, in order to restore it.

3. "The exciting action of magneto-electricity is manifested by the convulsive twitchings and pains in the ear, the momentary *increase* of the hearing distance, (which, however, very soon diminishes again, or, though it continues some time, it does not amount to any great degree,) and by aggravation of the *tinnitus*, either at the moment or some time after the sitting, and then more frequently during the night.

4. "Electro-magnetism or magneto-electricity (i. e., *induction* currents) *does not* thus appear to possess any peculiar *strengthening* action on the auditory nerve. On the contrary, great care is necessary in the trial or employment of this form of electricity, not to over-excite the affected auditory nerves."

I have quoted the foregoing apparently adverse opinion as regards the employment of electricity here, because of the high authority. But evidently Dr. Kramer is far more familiar with the one side of the question than with the other, i. e., as regards the anatomy and pathology of the ear and its surgical treatment, than with the therapeutical manifestations of the *various* electric currents. I agree with him, that all *Faradaic* currents of electricity are usually painful and fruitless, when applied to the internal ear; but this is by no means true of the *primary current of galvanism* when properly managed, nor is it true of friction or static electricity, when the operation is performed by introducing into the meatus the little, sponge-tipped, ivory electrode, and then "*drawing*" *short* sparks from the projecting silver wire of the ear electrode, as also from the external ear, say for one minute. Thus have I restored many a one more or less to his hearing, and at the same time annihilated the annoying noises. (See D.)

Deafness, depending on a true and simple paralysis of the auditory or acoustic nerve, may likewise be treated by galvano-puncture, and with the greater probability of success. After having tried the ordinary methods, by carrying the current to

the *membrana tympani* in vain, I have resorted to this still more direct application of the galvanic current to the very parts affected. A sound, insulated except at its small button-like tip, is carried through the nasal fossa, backward, until it strikes and is supposed to be at or near the opening of the Eustachian tube, (not necessarily entering the duct,) while the other electrode is armed with an insulated acu-puncture needle, whose point for one sixteenth of an inch is naked gold, which is to be implanted into the membrane of the *tympanum*. Of the Daniell's improved battery I employ from two to five, or even ten or twenty elements, (cups,) by making fixed contact, say with the nasal electrode, and then touching for a second or two the head of the acu-puncture (needle) that is in the ear, changing the direction of the current from second to second, or every five or ten seconds at most. Sometimes flashes of light are seen, and there is almost always experienced a metallic taste, while the shock is sensible, and not very agreeable. Patients that are impressible, sensitive, or irritable, should receive but one or two such shocks, and from only three to five cups; while others will bear five, ten, or even the twenty. It can be repeated every three days, or once a week, according to the effect produced. In well-marked cases of deafness, where the milder method was insufficient, this has awakened an entire cure, that, so far, proves to be permanent. (p. 233.)

Case of extreme deafness, and disease of both ears treated by electricity and cured. — Edward A. Goddard, of New York, aged twenty, was brought to me to receive treatment for almost total deafness; had suffered from disease of his ears nearly all his life. At three years of age he had scarlet fever; did not leave his bed for nearly a year; has had severe sickness since; is now decidedly a fine-looking young man, with fair skin and hair, but is evidently scrofulous; has had tumors cut from his neck, which were probably enlarged lymphatics; has been under the care of the most eminent men in our large cities, for this deafness, which was not a whit better, but grew worse, and was now almost a total deafness in both ears. During all these years there has been more or less discharge from the ears, and of late this appears to have been increased by the treatment from professed aurists. Such notes I gather from my case book.

This case was put under electro-therapeutic treatment (simply aided by a very weak wash of iodide of zinc) in February of 1859. He remained with me, receiving at first the daily *seance*, then on alternate days, then three, then two a week, — in all, for four months. At the end of that time his hearing was completely restored, together with a far more healthy tone in and about the ears; the discharges entirely done; the perforated tympanum healed! That both drums were perforated was proved by pouring a tea-spoonful of water, tea, or camomile tea in the ear, and it ran into his throat and mouth so readily, that he would always tell correctly what had been poured into his ear. This I saw repeatedly done, in the presence of other physicians. It is now more than one year since the recovery, and his correctness of hearing is scarcely equalled by the best. He is now perfectly well, and is a salesman in a store in Milk Street.

Indolent Ulcers.

"Indolent ulcers" are very successfully treated by electricity. The first attempt was made in Russia, by Dr. Crussel, of St. Petersburg. He first employed, for this purpose, *the direct chemical action* of the constant voltaic pair, applied immediately to the patient; and he termed this method of his the "*electrolytic treatment*." More recently it has been extensively employed in the hospital at Cronstadt, since the war, and that with very remarkable success in curing indolent ulcers. The results there obtained show that there is thus produced a rapid growth of healthy granulations and sound cicatrization of otherwise incorrigible old ulcers. Indeed, this method of treating ulcers has been occasionally put in practice in many nations, from our own country to the East Indies, and as far as can be ascertained, there is but one testimony, and that is, that no other means known in surgery is so capable of modifying the low, morbid vitality, and producing so uniformly a rapid growth of healthy granulations in old and ill-conditioned ulcers as by the continuous current of galvanism, and that, for example, from a *Humboldt battery.* It is rapid, and has no detracting contingency.

It is not necessary to blister the skin. Indeed, we are to understand that here we do not employ the "electrodes" of any battery, but rather the plates themselves, which are applied to the sound surfaces of the limb or body, and so act. That is to say, two disks of metal — the one of silver, larger but thinner than a Spanish dollar; the other of zinc, and a little larger than the silver — are applied directly to the skin; the silver is placed a little beyond or below, just on the edge of the ulcer, while the zinc is some few inches above it on sound skin, and so placed that the sore is brought between the two plates. Only, the plates must be moistened and covered with rubber cloth, or oiled silk, and the whole bound closely on so as to *sweat* and keep moist. If not, they must be repeatedly moistened. The two plates must be connected by a wire conductor, and this wire must be completely *insulated* from the body. It is better to use the Humboldt battery, which is ready prepared, and admirable for this purpose — it is invaluable. (See pp. 114–118, 154, and App.)

Indolent ulcers, then, can be readily aroused to take on a sound, healing condition, by means of galvanism alone, even where all other good treatment has failed. But, before an external ulcer heals, there is deposited the *cytoblastina*, in which organic and fibre cells are found. These, then, first give rise to *granulations*, which, as soon as they become level with the adjacent parts, are usually covered with a persistent membrane. This process is called "cicatrization," or healing. The electrolytical and stimulating power of electricity by induction may be employed in almost all such cases, if gently performed, and with great assurance of success. But my own experience leads me to prefer the action of the little Humboldt battery for this purpose, applied so that the silver plate is below and beyond (but close by) the border of the ulcer, while the zinc plate is above and nearer the body. That is, the plates are to be so applied that the one is *on* the ulcer or below it, while the other is above, and thus worn for about half of the time. But the electro-magnetic currents simultaneously applied to the limb so af-

fected, will also aid in vitalizing the flesh, and so fortify it against others breaking out afresh.

Nothing can compare with the rapidity with which a new character is given to the flabby granulations of a torpid ulcer by this little galvanic pair; even in the legs of old people, where, through want of vitality in the part, the sore will not heal. If very torpid, I apply the silver disk so as to cover the ulcer; i. e., lay the naked silver on the raw sore, for it is not painful, and it is often perfectly astonishing to see how quickly red and healthy granulations spring up under it, and the tedious sore is speedily and soundly healed. Should the healing be slow, however, then make a cantharides blister near by the ulcer, and remove the raised cuticle of the blister, and apply the zinc pad over this site for a part of the time. Thus, old, ill-conditioned, and "indolent ulcers" can be healed, that may have long resisted every other treatment.

Electric Moxa.

Dr. Wells, an English surgeon, and Dr. Golding Bird, also, observed, some years ago, that if two disks, the one of silver and the other of zinc, are placed respectively on two blistered or otherwise raw surfaces of the body, and contact, as by a wire, is made between the plates, while the wire is insulated from the skin, and the action is thus maintained, say for two days, more or less, the surface beneath the silver plate was found healed over, while that under the zinc plate was converted into a superficial eschar. If the plates were replaced and maintained still longer, then the eschar deepened, so as to extend to the sub-cutaneous cellular tissue, and to present all the characteristics of a slough, produced by chloride of zinc, or caustic of potash, except that the dead tissues were less compact. He noticed that the separation and cicatrization of such a slough is very tardy; but that it heals at once if covered in part or whole by the silver plate, the zinc being moistened and fixed any where upon the sound surface near by. The "*electric moxa*," thus made, is valued by some most distinguished medical men for certain cases of brain affection, as well as for pain and paralysis. (See pp. 114–117.)

Galvano-Puncture for Aneurism.

MM. Baumgarten and Würtenburg, after the fact announced by M. Schuh, "that coagulation is produced more promptly at the *positive* pole than at the negative, instituted experiments upon the action of each pole, taken separately." * They obtained the following results: —

1. If the negative pole of a galvanic battery was introduced alone *into* a vessel, the positive pole being at the same time applied against the neighboring parts, there was no coagulation.

2. The two poles being introduced at once into the vessel, produced slow, feeble, but rarely *complete* coagulation.

In order to turn these results to use, it becomes necessary to inquire, "What is the action of the poles upon albumen, fibrine, &c.?" M. Steinlein has undertaken this, employing Grove's battery, with poles of platinum and zinc: the first is positive; the second is negative. The experiments upon albumen gave the following results: —

1. If two conductors of platinum are plunged into a solution of albumen, no coagulation is produced; and test paper shows no reaction.

2. If the platinum needle of the *positive* pole be replaced by one of steel, then little bubbles are disengaged from the negative pole, forming a thick layer, and the reddish test paper that is applied to the platinum needle (*positive*) becomes blue, and the steel needle becomes slowly covered by coagulated albumen, with no disengagement of bubbles. This needle also becomes bromeo-colored.

3. If a zinc needle be used in the place of the one of iron or steel, the coagulation is much more rapid.

It follows, from these experiments, that the coagulation of albumen takes place *only at the positive pole*; and that the coagulating force varies according to the nature of the metal electrode that is employed. The author then endeavors to explain these results according to physical and chemical laws; and he advises,

* Teib. der Gesell. — Med. Times and Gazette, Dec. 16, 1854, p. 620.

in electro-puncture, that the steel needles should always be superseded by those of *zinc;* or rather, by needles covered by a layer of this metal.

The "galvano-puncture" should then be practised in the following manner: A certain number of needles, connected with the positive pole of a galvanic battery, are inserted into the tumor, whether the sac of an aneurism, or the cavity of an aneurismal varix. The negative pole should be supplied with a plate of platinum, which must be put upon the skin *adjacent* to the aneurism, after having augmented the conductibility of the epidermis by moistening it with a saline or acidulated solution.

Aneurisms of large arteries have been successfully treated by galvanic currents, and there are some such cases which must otherwise prove fatal, for they can be cured only by this means, if at all. Even these desperate cases present some chances of success, although not without some pain, and some little danger; and yet I believe not necessarily so, if carefully performed. The electric treatment here is based, then, upon the property given to living blood *while being traversed by an electric current*, i. e., of *its coagulating at the positive pole.* This, it is known, also takes place with albumen, in or out of living tissues, as Dr. De la Rive says, "probably by a secondary effect of an acid, liberated only by a law of action at the same electrode, from the decomposition of a salt, one of the constituents of the blood, and of albumen."

In this operation, it is necessary to introduce the electro-puncture needle well into the centre of the aneurismal sac. I say *needle*, for one is sufficient, although heretofore two have almost always been employed. That needle must connect with the *positive* pole of the battery, while the other electrode may be a sponge, or a metal covered with wet wash-leather, which should be applied to the skin *very near* to the former pole, *but on the opposite side of the aneurismal tumor* from the place where the needle enters. Then the continuous *primary* current from about twenty elements of Daniell's battery is required to produce the coagulum; and to this end, the current should be

maintained for about twenty or thirty minutes. A half hour is usually better than less.

We have found this to have been entirely successful in a number of these cases; some, where compression could have been employed, but the patient preferring this method; but in other cases, where neither compression nor the ligature could possibly be brought to bear, as shown by some given illustrations. But first I wish to say that the *needle* is generally required to be of *gold* or *platinum*, at least so as not to oxidize in the blood. But my preference is for an untempered steel needle, whose point is heavily gilded or platinized for a quarter or half inch of its point, and then the remaining portion of its shaft heavily covered with hard japan, yet so as to leave a good metallic head or eye at its outer end, for contact with the conductor of the battery. These are indeed the same kind of needles I always employ for deep *electro-puncture*. If the japan is well baked in, the shaft of the needle is polished, and yet completely *insulated*, so as not to injure the walls of the sac, in the least.

In the London Lancet of July 30, 1853, p. 94, is reported a case of aneurism of the external iliac, that was cured with electro-puncture by means of the secondary current of *electro-magnetism!* The patient was a sergeant in the Madras Fusileers, and as no other attempt at radical cure was thought justifiable, Dr. Eyere proceeded to operate as we will show in his own words: "I had met with some cases recorded where galvano-puncture was successfully resorted to. It was either in aneurisms of small vessels, such as the temporal, or at least where the compression of the vessel could be for the time maintained; for this was then regarded as essential. In this case, owing to the situation of the aneurism, it was impossible to effect good compression; nevertheless I thought, under the circumstances of the case, I was warrantable to give electro-puncture a trial. On the 4th September, two long fine needles were introduced an inch within the aneurismal sac, each being connected with the wires of a galvano-magnetic machine. The object was to avoid shocks, and merely to pass a current through the sac. Pressure

as firm as could be borne was made above, but it was not sufficient to stop pulsation in the tumor. The sensible effect of *this* kind of electric current was, pain in the groin, and violent agitation of the whole body. At the expiration of twenty minutes, the needles were withdrawn. The tumor was still pulsating as before. Strict quietude was enjoined. For three days after, neither did the aneurismal tumor nor his general health give indications that any effect had been produced. On the 8th it is noted, 'Tumor painful; is in a nervous and depressed state; cannot sleep.' This condition passed off, and nothing presented worthy of notice until the 12th, when pain in the tumor recurred, and he was again in a nervous and restless state. Leeches were applied, and sedatives administered. September 16th, there was much constitutional disturbance, with violent inflammation about the hip. Treated with purgatives and refrigerants. On the 19th, the inflammation was subdued. The tumor was now larger, but the pulsation not so strong. Digitalis and morphia prescribed; 27th, tumor sensibly harder, and the pulsation fainter. October 6th, pulsation to-day is very faint; 8th, the pulsation is scarcely to be felt; 11th, no pulsation for the last three days; the tumor is hard and diminishing; no pulsation can be heard by the stethoscope for two inches above and below the sac; 20th, no return of pulsation, and the tumor is gradually lessening; limb has lost the numbness so long felt in it, and only complains of want of power to walk. The remains of the aneurismal sac feel like an enlarged inguinal gland, and are about the size of a nut. There is œdema of the leg still.

"In the case whose treatment by galvano-puncture, led me to try it in Sergeant H., the cure was effected by a *continuous* and *primary* current of electricity, producing immediate coagulation of the blood in the sac. One may infer this by the rapid effect in a case of sub-clavian aneurism: 'The tumor was felt to be becoming gradually solidified; and even before the withdrawal of the needles it had become perfectly solid, and pulsation was no longer felt in it.' In another case of popliteal aneurism, a like rapid effect was not attained, (attributed to the agitation of the patient;) still in twenty-four hours pulsation ceased, and in seven days he left the hospital, walking quite well.

"This was not the *modus operandi* in the sergeant's case, but inflammation, and the deposit of lymph that occurred, filled up the sac. This latter mode was a hazardous one, and was not intentionally induced. The electro-magnetic effect was probably too violent to produce the former, though the machine — an electro-magnetic coil (helix) — was used at its lowest power. Indeed, I thought at first too little had been done; but when I found the external sign of the inflammation going on within the sac, accompanied by such constitutional disturbance, I began to fear that too much had been done. I watched with solicitude for the dark spot on the tumor — the forerunner of sloughing. Happily, the threatened danger passed away. The patient was of sound constitution; he lay in a spacious, well-ventilated ward, and the season was favorable. Under opposite circumstances the event might not have been so propitious. I should reluctantly resort to it (electro-magnetism) again, unless I had the proper primary electric current under my command."

Acu-puncture may often be of the greatest service in some nerve affections, and in some cases it is quite adequate to success; it can also be employed in neuralgia, as where no electric machine is at hand, and where mustard, cupping, and the like fail to give relief. At least, this can be done to gain time, while getting an electric apparatus brought and ready for work. Then, by turning the switch of the machine so as to use only the primary current of the battery, by turning the connecting wires from the battery, not to and through the helix, but rather *directly* to the acu-puncture needles, and thus rendering them "*electro-puncture*," and they become instantly many fold more potent than simple acu-puncture, in overcoming obstinate local pain. But a current of more *intensity* will do better still.

I find the following case reported by Dr. Banks: "A surgeon was obliged to ride in bad weather, and that immediately after fatigue and perspiration. He was consequently soon taken with chills, which were quickly followed by some fever, general aching, stiffness, &c.; went to bed warm, but was no better:

the case was regarded as an attack of a neuralgic and rheumatic character, affecting the aponeurotic or muscular structures. The surgeon thus portrays his own experience: —

"'On the fourth night from the commencement of the attack, I awoke with a drenching perspiration and extremely severe pains, with tonic rigidity of the muscles of the chest, more especially of the left side and shoulder. The pain, on attempting to move, was most excruciating. I found myself unable to expand my chest, and the breathing was wholly abdominal. I could not move. A sense of oppression and heat about the sternum kept increasing, and the dyspnœa became so urgent that I was fearful effusion was taking place in the pericardium. Dr. Banks was called in, and immediately proposed acupuncture. In the course of a minute or two after the insertion of the first needle, which was pushed inward and downward until in contact with the lower portion of the sternum, and while I was sitting up, I experienced a sensation as if some strong, tense structure, which had previously bound down the sternum, had given way. This sensation was followed by a sense of approaching syncope, which was removed by lying down. While in the recumbent position, I now found, to my surprise and delight, that I could take a deep inspiration freely. But the muscular pain still continuing, and encouraged as I was by the great relief in my breathing already afforded, I now, on my part, anxiously wished for the introduction of other needles along the course of the fibres of the several muscles affected. This having been done, I felt, in the course of about ten or fifteen minutes, no uneasiness whatever in the chest, and was able to move about in any direction; indeed, so great was the relief, that after the removal of the needles, I was able to dress myself with ease. I felt well. On the following evening, and for about a week after, I felt some stiffness (but no pain) in the left side, which, with a second insertion of three needles, together with a slight anodyne, was entirely removed.

"'In this statement,' the doctor proceeds to say, 'I have endeavored to relate my case and personal experience in simple acu-puncture as faithfully as possible, and I find it difficult now

to express in words the rapid and most extraordinary relief—as by a charm—that was afforded by the insertion of the needles. Beyond the narration of the case, I have forborne to offer any remarks.' "

Where there is a constitutional origin of such pain, in a recent or old case, as organic disease, *inflammation*, or inflammatory rheumatism, or hepatic engorgement, no permanent relief can reasonably be looked for from acu-puncture, nor even from galvano-puncture. But as the editor of the London Lancet says, " In all cases of rheumatic and neuralgic pains, either acute or chronic, whether lumbago, sciatica, or pleurodynia, or pains of an erratic kind, no matter where situated, if not depending upon an inflammatory state, or upon a constitutional origin, or upon organic disease, and provided the patient is *most comfortable when warm, and is decidedly relieved by the application of heat*—in all these cases, it may, I think, be *confidently affirmed* that they will be singularly benefited by acu-puncture, which will not only afford relief, but in most instances will effect a cure." And where acu-puncture fails, there often galvano-puncture is entirely victorious. Besides, a less number of needles, and less length of time of insertion, and a less number of insertions, are required by the latter in order to be successful. (See p. 477, and Appendix F, G.)

Un-united Fractures of Bones.

A case of fracture of the thigh bone is reported by Dr. Hall, of the York County Hospital, as having been cured by galvanic currents, in the following manner: He introduced a fine but long acu-puncture needle into each side of the limb, so that their points came near the inter-space between the fractured ends of the bone, and thus he passed, for five minutes, a current of moderate, continuous, and *primary* galvanism. This operation was repeated every day for about a fortnight, and a cure resulted. The fracture of this leg bone having been very movable, and having existed thus un-united for more than a year, had resisted every other means that had been attempted.

The author has seen but few cases of un-united fracture of bone since he has been more particularly interested in this special practice of electro-therapeutics; but he can add, that no case of these few has ever failed to be speedily united by means of electro-puncture, aided by the passage of some stronger currents, primary or secondary, through the skin and muscle coverings. The following is given as the mode of proceeding:—

Captain G. fell, more than two years before, from the staging of a new ship he was then building, and broke his thigh at its upper third. He was cared for, the best possibly, by our most able surgeons; but he was restless and irritable under the long restraint, and, after months, it was found that the bone was still un-united, and, therefore, the seton, with tonics, together with magneto-electricity, were resorted to, and persevered in for a long time. His limb had been so long retained in splint, however, that pseudo-anchylosis of the knee joint was the result, and this then rendered the fracture an almost necessary artificial joint, and still more hopeless of ever being kept quiet long enough to unite. But, in the first place, I had provided for the captain the improved surgeon's bed for fractured limbs, upon which he was comfortably adjusted for a siege of twenty-one days, which was all I demanded for a fair trial in his case, and at the same time prognosticated as favorably as I could. To this he agreed to submit. The broken right thigh was then prepared with the sustaining broad roller from toes to hip, and the limb placed once more in the same excellent splint that had been used by the surgeon in the first instance when he set the fracture. Then the long size electro-puncture needles were inserted through the roller, skin, fascia, and muscles, the one entering rather at the upper inner edge of the *rectus femoris* muscle, avoiding the femoral vessels and nerve trunks, and carried down until its point touched the bone as near the fracture as possible, while the other needle was inserted on the outer side of the thigh, through the *vastus externus*, and pushed forward until its point reached the bone. These needles were of fine gold, and insulated, except at their points; or *un*tempered steel needles, some three or four inches long, heavily gilded for a half inch at

their points, and their shafts covered well with hard japan for insulation, will do well. The insertion of the needles was attended with no pain worth mentioning, and the primary current, from ten elements of Daniell's battery, was brought in contact with the heads of these needles continuously for five minutes, and so on three times at the *seance*, and thus repeated every three days for the first nine days. After that, the current was applied daily from large soft sponge electrodes, as employed for neuralgia, to the loins and limb through wet spots on the roller. Thus the case was treated until the twenty-one days expired, when the patient was set free once more from the splint and bed restraint, and to our mutual gratification, the thigh bone was found fairly knit together, and the leg was stiff. The subsequent treatment at the knee joint and about the limb was the same as would be instituted for an old rheumatism. In a fortnight more, the limb felt to him more secure and comfortable, and what was quite as pleasing and surprising, the pseudo-anchylosed knee also began to show a loosening and joint-like action. This became more and more apparent, so that in three months the captain was prepared to think of the sea again, as he now walked well, and accordingly arranged for an East India voyage.

Electric Cautery.

Galvanic cauterization by the "*electro-caustic*" (heat) has received some attention at the hands of surgeons both here and abroad. This operation is based upon the calorific properties of galvanic electricity of *quantity*, as when from some five or six of Bunsen's or from a dozen elements of Grove's battery. For the purpose of avoiding the "firing-iron," and in cases of *nævus* to avoid hemorrhage, and for a moxa, Dr. Fabre Palaprat was the first to employ the red-white heat of a platinum wire, made so by a voltaic or galvanic battery. In 1845, Professor Steinheil, of Munich, advised a method for cauterizing the pulp of the dental nerve in decayed and painful teeth, which in that year was accomplished by M. Heider. Dr. Crusell, of St. Petersburg, operated, in 1846, with a fine platinum

wire rendered incandescent by voltaic electricity, — drawing the wire back and forth, like a saw, across the base of the tumor. He says he found that, when adroitly managed, there was produced neither pain nor hemorrhage. In England this has been repeated, and of late with admirable success. M. Nelatin, ever since the year 1850, has been making use of it for destroying and curing erectile sub-cutaneous tumors, and at the same time *preserving* the skin.

Dr. M. J. Regnauld, of Paris, by extensive practical and candid research in this province, is inclined to limit the utility of these electric cauteries; i. e., he admits their great excellence under certain special conditions. He says the first obstacle is the want of a great battery power; the second is, that the smallness of the platinum wire allows it to cool in the moist tissues, if held still; but where it can be sawed back and forth, it will not cool down as if heated by a fire, because the heating is all the while going on, and the instant the wire draws out at one side of the wound it is sufficiently hot, and can be as quickly drawn back again with effect. But, after all, the wire does not retain its heat amply for general surgical use, and this is a great obstacle. He not only admits, but admires, the advantages of this method for special cases, as near delicate soft parts or organs, and where of little extent, or is hemorrhagic, and in deep, narrow parts. For the best success, he advises patience, and repetition of the application at different stages, and when the wound has dried from time to time.

In hospital practice there is an incontestable advantage as an auxiliary to surgery that certainly would justify the maintaining a set of some five or six Bunsen's jars of coke, or a dozen of Grove's, or a Cruikshanks' trough of fifty pairs, which indeed could be well employed often for other equally important operations.

In 1855, Dr. Middeldorpff published a very valuable work on the subject of Galvano-Caustics. The instruments he used for these new and peculiar operations in surgery he termed "galvano-port-ligatures," galvanic cauteries, galvanic setons, &c.; drawings of which, accompanied with a paper from Dr.

Coolidge, of Chauncy Street, was published that same year in the Boston Medical and Surgical Journal. These instruments should be made of *heavy gilded* copper, tipped with platinum wire, when used as a loop or saw; but when used as a probe or point, then tips of *platinized*, untempered steel are preferable. The advantages of the galvano-cautery in all this class of operations, according to Dr. Middeldorpff, are, the exact intensity of heat and precise line of limitation of the effects of the operation; the rapidity and cleanliness of the action; the total absence of hemorrhage; the ability to reach and remove the deep-seated parts, such as it is impossible to get at with the ligature or knife; and, finally, the uniformly good character of the fleshy cicatrix. He reports numerous and varied cases so treated, and with very uniformly good results. With it he claims that we can cure neuralgias in the most desperate cases, even where nothing but destroying the nerve can relieve; we can use it as a *moxa*, or for certain rheumatical and superficial paralysis; for *nævi*, *polypi*, and other vascular tumors; for gangrene, ulcers, cancers, and especially for *fistulas*. He succeeded in the bloodless amputation of a deformed finger in a young lady, cutting not only through the soft parts, but also the bone, which rapidly got well.

Dr. Marshall and Dr. Amusat, and some others, choose a short bit of platinum wire as the electrode, about one fiftieth of an inch in diameter, and not more than three inches in length, for curing ulcers and removing growths upon the unhealthy *cervix uteri;* also for removing cancers from those parts.

Dr. E. H. Clarke, of Chauncy Street, Boston, professor in the medical department of Harvard University, informed me, a short time since, of his entire success, by this means, in removing a deep-seated tumor from the ear passage, that had thwarted all other efforts, or even attempts, *because of its hemorrhage nature* — a profuse bleeding occurring on the slightest touch. He states that this cautery left only a gray eschar on the side of the bony canal, near the *membrana tympani*, which did not bleed. The result appears, so far, to be a complete cure. I should have mentioned that in this case

Dr. Clarke first passed the loop of wire over and beyond the little tumor, and then, as soon as contact was made by an assistant, the platinum was instantly seen to be red hot; he drew it forward gently, when it shaved the neck of the mass clean and close to the bone.

Not for all cauterizations, I conclude, but for certain cases, the galvanic cautery can be employed with decided advantage. It acts rapidly and with energy; it causes but little pain, and no hemorrhage; its action may be exactly limited to the precise spot or line; and it always favors the growth of *healthy granulations*, for it probably modifies the vitality of the diseased part; and, finally, it is no way so terrible to the patient as the red-hot iron, or the *aqua fortis*. It has been used, and approved of, also, by Amusat and Nelaton of Paris, Hilton and others of England, and Sedillott of Strasburg. There appears to be but one single drawback to the very extensive employment of this excellent therapeutic in surgery, and that is, the difficulty of having sufficient battery power always ready for action. And this objection must greatly prevent the employment of this agent, otherwise so desirable, excepting in hospitals, where it certainly can and ought to be always in ample readiness contiguous to the operating room.

Urethro-vaginal fistula has been operated upon with the galvano-cautery at St. Bartholomew's Hospital, by Dr. James Paget. The case is reported in the Lancet, June 9, 1855. The woman had never been married, was of about thirty years of age, was healthy, but had an old-standing and troublesome fistula between the vagina and urethra. As the case had been the subject of repeated and fruitless operations at various hospitals, and very many modes of cure had been tried in vain, Dr. Paget had recourse to the electro-cautery. The case is one of very great interest, because it shows the adaptation and beautiful application of localized and *concentrated* electricity in surgery. The writer goes on to say, —

"We lately spoke of the usefulness of the actual cautery in hemorrhage, as after lithotomy, and in chronic synovitis. Every one, however, must have observed the clumsiness and hurry with

which the red-hot irons are taken out of a smoking brazier, and the horror they create in the patient's mind. The galvano-caustic, on the other hand, requires no fire, no smoke, &c. The essential part of this apparatus, not unlike a glazier's diamond, or ordinary port-caustic-case with two wires run through it, may be carried in a pocket-case. When in action it applies a little coil of platinum (twisted around a bead of glass or porcelain, about the size of a small pea, and of a *white heat*) to any part, or for any length of time that may be necessary. In the present case the effect was almost like magic. The incandescent little '*pea of fire*,' produced within the *speculum vaginæ* by the operator in an instant, quite lighted up all to be seen, and plainly showed the amount or extent of disease, almost as in a diagram.

"The plan of operation, to which we would revert for a moment, was very simple. An ordinary galvanic battery, of some half-dozen plates, was placed on a chair at the side of the bed; the two wires (conductors), the one attached, the other in the operator's hand, were next arranged. The second conductor wire only required to be pushed into a hole at the opposite end of the battery, by the left hand, and the operator could have instantly produced in his right hand this little ball of fire, at a white heat.

"The woman was next placed on her hands and knees in bed, without any exposure. The speculum was introduced, when the vent or fistulous opening was at once seen to be about a half an inch in extent. The circuit of the battery being now completed, the coil of fine platinum over the bead shone at once with almost too much light, reflected as it was from the glass mirror and silver of the speculum. Dr. Paget then carefully pencilled the edges of the fistula with this new, and we think improved, actual cautery, just as if it were a pointed piece of nitrate of silver. The woman, strange to say, did not feel the least pain — a *peculiarity*, it is said, of the '*white*' heat, as contradistinguished from that of a lower or red heat. She did not require ether, and after the operation she seemed as if nothing had been done to her. We mention these particulars, because such an improvement as the galvano-caustic, over the old red irons, can-

not fail to be of use in burning out the seeds of cancer after removing a cancerous tumor, or in destroying even to the minutest point or speck the various morbid growths for which the actual cautery is generally used.

"This operation was performed May 18. On the 21st, when visiting this woman to-day, she expressed herself quite a new being, as she can now retain her urine three times as long as she did formerly. It is too early, however, to form a decided opinion. — 23d. Marks of improvement are beginning to be quite perceptible in the woman's countenance. She states that she has not been so well for 'years and years.' — June 4. Dr. Paget is quite satisfied with the good result of the operation. The remedy in this case has been an interesting one, as a galvanic experiment, free from pain, and ultimately effectual after other operative proceedings had failed."

SURGICAL DENTISTRY.

The Faradaic Process in Tooth-Extracting.

The magneto-electric machine that I employed while making my researches in this particular line, the year immediately after my return from Europe, was a very simple and neat apparatus, and is now extensively manufactured by Mr. Hall, for dentists' use. It is the neatest machine for office practice, either for the physician or dentist, that I have ever seen. The helix is *long*, and completely covered with a silvered band and ivory ends, admitting a very delicate graduation of the current, by the adjustable rod or bundle of soft iron wires within. A Smee's battery is employed to run the helix, and requires cleaning only once a week or month. One part sulphuric acid, with fourteen parts water, runs the battery suitable for dentists' use. The negative (strongest) pole is to be attached to the forceps, while the positive (weaker) pole is either applied to the nape of the neck, or under the ear, of the side the tooth is to be extracted, or else held in the hand of the patient, *on the same side* the tooth is situated. The adjustable attachment or contact of the negative

conductor with the handle of the forceps is conveniently made by a few inches of rubber tubing of a size that will just slip over the end of the handles. This rubber tubing I found to be at the same time the best thing for insulating the instrument from

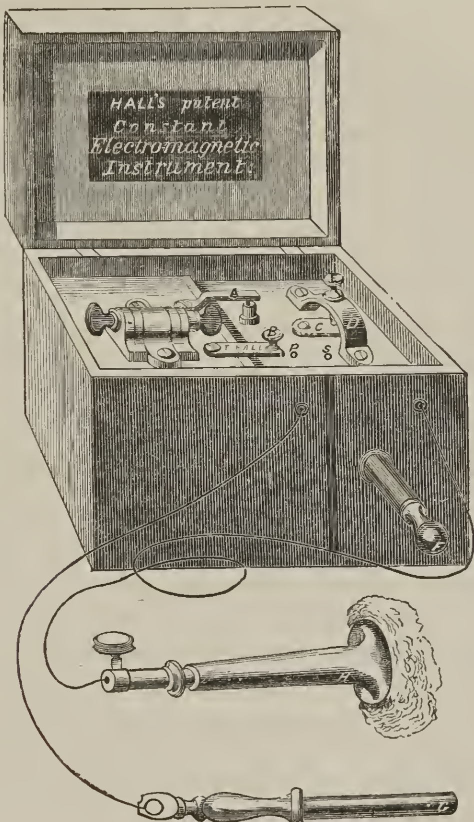

Fig. 96.

the operator's hand. The outside of the forceps, about its joint from the rubber handle covers, to the very edge of the beaks or blades, should be well covered with varnish, or, what is better, with hard japan varnish, so as to insulate every instrument perfectly from the lips, cheek, and gums; but *the inside of the beaks* or jaws, on the contrary, should be the clean steel, (even clean

from dried blood,) so as to *conduct* as *surely* to the periosteum of the tooth, as the outside *insulates* from the gum.

The wire tip of the conductor can be slipped under the outer end of the tubing that covers the handle, and this wire can be pulled out and slipped under the thus prepared handles of any other forceps in an instant. The conductor that leads to the forceps should be made to pass through an interrupting footboard, such as is used for telegraphing purposes, so that the current can be made or broken instantly, at the command of the operator.

Another precaution I would here mention. I have found that when there is oil in the joint of the tooth forceps, one blade is liable to be thus insulated from the other, and so fail to convey the current to both sides of the tooth. To avoid a failure from this cause, I have the terminal end of the negative conductor provided with two terminations, which are some six inches in length, each of which I tuck under the end of the rubber of each handle of the forceps to be used. This simple arrangement alone will nearly double the uniformity of success in this delicate operation. So much for the preparation. Next, for the operation.

First, the electro-magnetic machine should run with fine vibrations, and at a very moderate *battery* power, but with a smooth and even current. Next, the intensity of the current should be graduated down to the nervous impressibility of the patient. The adjustable rod, or bundle of soft wires, are graduated and marked off with sixty degrees. Some young ladies, and some men, too, can bear only ten degrees; others will require twenty; and some hardy nerved or phlegmatic temperaments can not only bear, but say they do but just feel, forty degrees. For the young operator, it is well to let the patient take the two poles in his own hands, and then adjust the strength of the current by the magnet until he or she can very agreeably feel it, but no more. Then adjust the positive pole in the patient's hand, or over the *portio dura* nerve, or on the nape of the neck, while the heel of the operator rests on the floor near the footboard, ready to make or break the circuit of the current at any moment. Now, when *quite sure* that all is right and ready, carefully slip the forceps on the neck of the tooth, until it rests gently against the gum,

ready for a better or deeper hold; and as this is being done, that instant *let on the current*, *grasp the tooth*, *and pull* systematically and carefully in the same order and about as quick as a person can say, *one*, *two*, *three;* so I say, make contact (press the foot) for *one*, *grasp* the tooth for *two*, *pull* with a waving motion for *three*. The two former motions can be practised until exact, and without a failure. The latter cannot always be *limited*.

The current seems to *mask* the pain for about five seconds, as near as I can judge from all my trials. If, then, the current was let on right, and the tooth fang leaves the alveoli and gum before that time is up, it is a success. When the tooth *hangs hard*, and is slow in yielding, I break the current, slack the pull, and then make it again with a renewed pull. So if the battery current is too strong, or is irregular, or fails to pass; or if the forceps are not *perfectly* insulated from the operator's hand, as well as the patient's lips or inside of cheek or gum; or if the current is let on too soon, or, on the other hand, if it is let on too late, i. e. only after the *pain* is already established from the crowding forceps upon the inflamed gum,—in either case, I say, it is *necessarily* a failure. But when all these conditions are complied with, which is only like any other exact but eminently practical art, there is a success that may be called *complete* in every eight cases out of ten. I would not include cases of "fang pulling" when there is a protracted process of "getting hold;" but in fair cases, when the adroit operator can readily adjust the beaks of the instruments on "a good hold," the operation is then more like pulling wooden pegs, than like tearing bone from bone. For single tooth extraction, my experience leads me to say, electricity is far preferable to ether.

This, although but a partial improvement, yet, like etherization, is of American origin. It can be shown that I was experimenting in this line all the fall and winter before Dr. Francis made public his experiments in Philadelphia, being led to it while making trials with different electric currents in surgical cutting operations. I found that the periosteum of bones almost every where received a peculiar impression, not exactly

painful, but decidedly sensible, the instant the edge of the knife or scalpel reached it, while conveying a *gentle* current of electricity, *provided* the blade and back of the knife were insulated, so that the current could not reach the wound except at its very edge. This was most noticeable in opening felons. Being then, as now, perfectly aware that *such currents of electricity have no sort of paralyzing power*, yet it struck me that if this instantaneously produced peculiar *impression* could be brought to bear upon the periosteum of the tooth *while it is being extracted*, it might be found to *modify* the sensation of pain. I did not expect to find such a current, in any absolute sense an anæsthetic agent; and those who do, are hasty in conclusions, or else know too little of the laws of electro-physiology. I claim that here it is through the periosteum of the tooth, that the *pre-occupying impression* of Faradaism supplants the quickly succeeding and partially simultaneous painful impression of extraction. The two impressions appear to be something like a race; but in order to have the *electric impression* beat the *pain impression*, the former must have a trifle the start.

I say it is probably through the peculiar properties of the periosteum or *surface* of the tooth, that this *pre-occupying* or vicarious impression overshadows the pain of tearing, and is not through the contained pulp and nerve. A recently extracted tooth, when cleaned and well dried, is almost as complete a non-conductor of the electro-magnetic current as is ivory. I do not say it is completely so, but I do say it is a very poor conductor, and cannot transmit or convey the current through its body so amply as to account for the attending phenomena. It is more probable that the current does not penetrate the tooth, but mainly passes down its sides to its nerve at its exit from the fangs, and to the contiguous alveoli. This may be true, or it may not; but such were the reasons that led me so early and so far into these trials.

When several letters patent were proclaimed for the process, and litigation appeared likely to follow, I dropped this whole branch of experimentation for other fields in electro-physiology and therapeutics. At that juncture, however, the author made

a report of these so far ascertained facts before the Suffolk District Medical Society, exhibiting the teeth thus extracted without pain, from some sixty patients, and explaining the *modus operandi*. Some of our best dentists, who are experts in surgical dentistry, are now making use of this method in all suitable cases with highly satisfactory results. Dr. Keep, long known in Boston as one of our most skilful dentists, has just informed me that my method for the *Faradaic tooth-extracting process* removes "the dread of tooth pulling" in one half of the cases, expedites the process in quite a number of instances, and averts the necessity of administering ether not unfrequently.

Dr. J. N. Hearder, of Plymouth, in England, says,* — "A few words on the application of electricity in the various dental operations. Having lately been coöperating with my friends of the dental profession, in applying electricity *as an anæsthetic*, I have been led to conclude, not only from these experiments, but from the careful consideration of the experiments of others, that the results of all this are quite compatible with the conditions under which they are obtained. However various

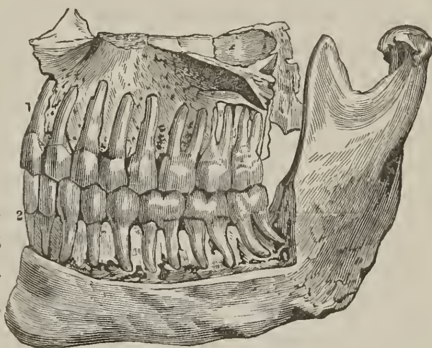

Fig. 97. *The Upper and Lower Jaws.* A Side View, showing the natural position of the Teeth *in their sockets*, as the outer plate of the Alveolar Processes has been removed, so as to expose the Fangs of the Teeth, and show the kind of articulation, and the relative position of each tooth. Fig. 69 will show the Nerves of the Teeth.

1. Nearest to the figure we see the Two Incisors of this (the visible) half, or side of the Upper Jaw. The next Tooth is called the Cuspidatus. Next to it are the Two Bicuspidati. Next, we see the Two great three-pronged Molars. The last tooth in the upper jaw is often also three pronged; this tooth is called Dens Sapientiæ. There are 16 teeth in the upper jaw.
2. Nearest to the figure again we see the Five Single teeth, which are similar to those that match them in the Upper Jaw. But the next three are double teeth, are called Grinders, and have only Two Fangs each. In the lower jaw there are also 16 teeth.

* London Lancet, Sept. 18, 1858, p. 297.

the opinions as to its efficacy, and however conflicting the evidence afforded on the subject, the failures appear to indicate little more than the absence of an efficient apparatus, or of the want of knowledge or experience in the application of it. Much more must be done in the way of investigation and *careful* manipulation, before individuals or societies will be in a fair position to pass judgment on the value of an agent so powerful, and, when in the right hands, so efficient. *The investigation of the causes of some of the failures shows, that the right effect would have been produced, had the right method and manipulation been adopted.* Much of the experience on this head will necessarily be empirical until the relations between cause and effect here shall be so far determined as to establish a sufficiently accurate system of prognosis, and definite method of procedure.

"One step towards the attainment of success in this speciality will be the employment of a *suitable* electro-magnetic *apparatus*, such as is capable of nice adjustment and easy application. The graduation of the current must be as *minute* as the manipulation is *delicate*. I have been in the habit of employing electricity for certain cases of toothache during the last *thirty years*, and have relieved hundreds of cases, most of them permanently, many of them for a considerable period of time, some only temporarily, and very few not at all.

"The cases of toothache which yield most readily to this treatment are those in which the pain originates in the tooth itself. Those in which the pain results from a neuralgic affection require a modified and more continuous treatment; but, as might be expected, in those cases where there is *abscess at the root of the tooth*, the pain is usually increased.

"My mode of electric treatment here is to apply a metal disk, covered usually with moistened cloth, and connected with the *positive* pole, which is placed on the back of the neck; placing a similar disk connected with the negative pole either on the tooth itself, or on the gum, or by passing this second disk along the course of the nerve, or its branches, exteriorly on the face. The degree of electro-magnetic power that is necessary, *is very feeble.* So efficacious is this remedy for *toothache*, that some

of my own children, who suffer occasionally from defective teeth, apply it for themselves for a few minutes, and return to their room relieved from pain, and sure of a comfortable night's rest."

We have just said that the *Faradaic tooth extraction* is of American origin; but we see that a wide attention is awakened in England on this subject. Mr. Sharpe, the dentist for the Chester Infirmary, says he has lately "extracted one hundred and fifty teeth from people of all ranks, of both sexes, and of every age. The testimony of each of these has been mostly satisfactory; a current of electricity having been directed through the tooth to be extracted; some persons said they experienced pain, but not so much as usual; others, that they felt no pain whatever. Some patients have said, they were 'conscious of the pull, but the customary *pang* was absent.' The exclamation of many, after the operation, has been, 'O, how delightful!' 'How very nice!' '*How very wonderful!*' &c. One gentleman, who was rather sceptical, after having a tooth extracted, said, 'Well, I would not disbelieve a man now if he should tell me he had learned to fly.' Feeling desirous of getting as satisfactory evidence as possible, I persuaded my youngest son, who is not more fond of having his teeth drawn than other boys of his age, to have a temporary molar tooth removed in this way, in order that he might be able to tell me what he thought of it. As soon as the tooth was out, he exclaimed, '*That's the thing. It will do it, papa.*'"

Dr. Lobb, of the Western General Dispensary, says, "I have now used the *inverse continuous current* of electricity (galvanism) for more than twelve months, for the cure of *some forms* of neuralgia, toothache, &c. I have never used it to prevent pain during the extraction of teeth, but from what I know of its success in toothache, I have no doubt it will yet be found to be perfectly successful." Dr. Richardson, physician to the Royal Infirmary, &c., says in a recent paper, "The present unsatisfactory mode of preventing pain in surgical operations must unquestionably be ultimately superseded by some better process. It will be read of, some day, as a rude science that leads the whole human organism into the *realm of dissolution*, in order

that one poor molar may be dragged out without a flinch." Dr. Arnott thinks it is even so now. Any mode of producing local anæsthesia, — I mean complete local anæsthesia, — without injury, lies open, at this moment, as the grandest practical discovery to be made in medicine; and he who makes it can be grudged his well-earned fame by none but the selfish and the foolish. (See Appendix D, Note 1.)

Galvano-Cautery for the Teeth.

Who, of our own dental surgeons, was the first to use the elegant *galvano-cautery* for destroying the sensitive nerve-pulp of decayed teeth, either to relieve pain, or as preparatory to "filling," I am not informed; but it appears that Dr. Thomas H. Harding, of England, was the first to put it in successful practice in that country. I admire what he says of his experience in this matter. He remarks that Dr. Marshall's paper in the London Lancet, in May, 1851, first suggested to his mind this excellent method as the more certain, rapid, and safe manner of effectually obliterating the nerve of a decayed tooth. Many methods have been from time to time employed to direct the "galvanic heat" upon the tooth-nerve, but they have mostly been either inefficient or badly managed.

Speaking of other methods where the tooth is liable to be injured, as, by the "actual cautery," the substance of the tooth is *carbonized*, Dr. Harding says, now, all this liability is completely removed by using the electric cautery, which can never be surpassed for convenience and ready mode of application, besides possessing a steady, uniform, concentrated, and constant degree of heat, which can be continued at pleasure until the proper effects are obtained, and then it can be as magically stopped by breaking the contact of the conductor. It has the advantage, also, that it can be introduced unseen into the patient's mouth, and actually placed within the cavity of the tooth, before it is made to become incandescent (white hot) — an advantage that, for this particular purpose, cannot be overestimated by dental surgeons, who are so frequently called

upon to destroy a tooth-pulp. The nature of the apparatus which he employs for this purpose is thus described: The battery is what is termed *compound*, i. e., consisting of six pairs of large plates, the one of zinc covered with quicksilver, and the other a platinized silver, which are contained in six cells, or gallon jars of crockery or glass, (called Smee's battery,) which are set in action by one fluid, viz., dilute sulphuric acid. The battery may of course vary according to the choice and taste of the operator; but it is desirable to render it as elegant and as simple in arrangement as possible. When I first employed the electric cautery, I used a battery of two (large) pairs of plates in a single cell. I now prefer the larger battery, of six cells, because a large battery, with weak acid, will run longer than a small (or single cell) battery, with strong acid; besides this, the action of the battery *is more uniform*, and lasts much longer. A Smee's battery is the best for dental purposes. It is always clean, ready any instant when wanted, and has the advantage, moreover, of cheapness. Grove's battery is not so adapted to these purposes, because it is troublesome, and often gives out fumes of nitrous acid, which is decidedly objectionable. There is none of this trouble from a Smee's battery.

Dr. Braithewaite, in his "Retrospect," Part 36, page 296, makes some capital extracts out of the Quarterly Journal of Dental Science, from the pen of Dr. Underwood, on the "Treatment of the Exposed and Diseased Dental Pulp." The writer there says much in these words: The parts of the teeth possessing nervous *sensibility* are the *pulp*, or, as it is more generally termed, the "*nerve*," as also the *periosteum* and *the fine membrane* situated between the enamel and the bone. Mr. Tomes considers the sensibility of this part of the tooth to be owing to the nerve fibrils in the dentinal tubes. He says the greater degree of sensitiveness observable in the dentine, immediately below the enamel, that is, at the point of ultimate distribution of the dental tubes, and consequently of the nerve fibrils, may be fully accounted for on the supposition that the latter are organs of sensation.

No doubt the nervous filaments passing through the *tubuli*,

or else through the intercellular substance, form a plexus under the enamel which is highly sensitive. Every practitioner knows, that in excavating some teeth there is no pain whatever felt on introducing the instrument even into the pulp cavity itself; but that a sharp pang is experienced immediately if we touch the spot where the dentine and enamel come in contact. The sensibility, however, of this membrane need not interfere with plugging the tooth; no ill effects will follow it. That which is *toothache*, in the general acceptation of the word, proceeds rather from the actual exposure of the dental pulp, and is characterized by acute and violent pain. A portion of food, or any foreign substance, entering the cavity of the tooth and coming in contact with the pulp,—any thing very hot or cold,—in fact, if only exceeding in either of these respects the natural temperature of the mouth, immediately produces a paroxysm of pain along the whole course of the dental nerve, extending up the head, &c.

There are three modes of treatment open to the dentist in these cases. Should the affected tooth be one of the incisors or canines, the pulp may be removed either by a five-sided broach, or by pushing a straightened small fish-hook up the cavity of the tooth, giving it then a half turn, and withdrawing it quickly, and in nine cases out of ten you will bring along the nerve with it. The bleeding then may be stopped by the application of camphorated spirit; after which, remove all the carious bone, dry out the cavity, and plug it. The second plan is to destroy the nerve entirely. The third plan is to render the exposed surface insensible.

After speaking of the employment of arsenic, creosote, tannic acid, quicklime, and nitrate of silver, he proceeds to say, "The actual cautery (by galvanic heat) may often be resorted to with *great success* in instantly producing an eschar on the sensitive pulp, and in a few days the tooth may be filled. You first apply the wire of the cauterizer to the affected pulp *unheated;* then, by touching a spring, contact is made with the battery, and the wire is instantly at a white heat. Care should be taken not to wound the internal (deep) part of the pulp."

The *dentist's galvanic cauterizer*, as made by Mr. Thomas Hall, of this city, (see page 155,) may be thus described: The insulating handle is made of ivory or ebony, and contains some six inches of the terminal ends of, (or can be attached to,) the two battery conductors. These tips are copper wires plated with silver or gold, which are separately embedded in the ivory, and thus insulated safely, but so arranged that one of them can be opened or closed by a delicate touch of the thumb-spring. Now, on the extremities of these tips is a very fine piece of platinum wire, — say a hundredth part of an inch in thickness only, and three quarters of an inch in length, — which is bent into a loop, so as to *connect* the two poles. The sides of this loop are brought parallel and as nearly close to each other as possible without touching, so that the current must pass *around*, and in this shape it is introduced into the pulp cavity of the tooth to be operated upon, ready to be plunged upon, or into; the nerve as soon as heated; then, by a slight pressure on one side of the handle, the interrupted pole is temporarily united in good metallic contact, so that the platinum-pointed loop-tip instantly becomes brilliantly heated, and is then carefully pressed into the tooth-pulp. The flexibility of the platinum loop-tip, which is the cauterizer, enables the operator to bend it in any direction, previously to use, but always so that the current *must* pass around the very extreme acute angle of the loop, or all is a failure. In this way Dr. Harding says he has been very successful in quickly destroying the pulps of decayed and condemned teeth, and has proceeded, sometimes after only a few minutes, to the filling with gold, or other stoppings, as the metallic paste. The fact is, this instrument is nothing more nor less than Middeldorpff's electro-port-cauterizer, with adjustable tips for dentists' or surgeons' use. (See cuts of apparatus, page 155.) Of the *operation*, this celebrated dentist says, —

"The affected tooth being carefully examined, its cavity is to be well dried out and cleansed. A soft napkin is introduced, to protect the mouth; the platinum point of the instrument is then passed over or into the cavity of the tooth and when all

is ready, and well seen, contact is made, and it is thus heated; and from the brilliancy of the clear and distinct light there produced, the tooth-pulp is all the better seen, and can be accurately *touched*, and only so, with the heated wire, when the whole, or the particular portion of it required, is instantly destroyed."

It is well to mention, that caution is to be observed not to injure the solid part of the tooth. Particular care should be paid to this point. This will not happen unless the application is prolonged, which is almost never required, and if special care be observed to have the wire at a *white heat*. This is the more necessary, to produce the sure and speedy destruction of the soft part touched, which indeed is effected almost instantaneously. "In one instance," says Dr. Harding, "that of a lady for whom I nipped off the crown of an incisor tooth, for the purpose of fixing some artificial teeth, and so exposed the pulp of that tooth, I applied the electric cautery at barely a red heat, owing to the feebleness of the acid in the battery. The unfortunate consequence of this was, that the dental pulp became attached to the end of the wire, and was actually drawn out of the tooth entirely. This has been preserved as a pathological specimen. It gave some slight pain for the moment, but mere nothing in comparison to the pointed steel, or silver wire, as used by most dentists. This perhaps unimportant accident, I think, would not have occurred had the cautery been at a white heat, as it would then have as completely as quickly destroyed the soft part with which it came in contact."

"The *effect* of this operation," he says further, "is the rapid annihilation of the pulp of the decayed and condemned tooth. Not the whole of the pulp, for that is not always necessary; but that portion of it, especially, which is exposed. If this is adroitly done, with a *light*, steady hand, no subsequent inflammation is produced in the substance or cavity of the tooth. If there should be any marked sensitiveness in the tooth, independent of the pulp, then the slightest touch of the cautery to it will prove effectual in completely removing it. In the large number of cases in which I have employed the galvano-cautery,

I have never seen or known any bad effects produced on the tooth. This result must be connected with the uniform care with which this nice operation has been done.

"In whatever condition the tooth-pulp may be, the operation is attended with but very little pain. As the time of its application is but just a second or so, in the large majority of instances in which I have employed it, *there has been no pain whatever felt*. There may be a sort of twinge, which is but instantaneous. But whatever pain may arise is not to be compared to that from the process of extracting a tooth. Some of my patients have felt it so little while being applied, that they have asked me to apply it the second time, so as to make all certain that the nerve was killed.

"If the cavity of the tooth so treated be minutely examined, a small black speck or spot can be seen after this cautery has been correctly and *successfully* used; this is the result of the carbonization of the pulp, and is a guide, to some extent, in the after process of removal of the carious portion of the tooth, which should always be done after the sensibility has been destroyed by the electric cautery. It is to be accomplished in the usual manner, with care, taking the precaution to leave none of the tooth that is decayed, as every particle of it should be removed, just as in any case of filling. For a few days afterwards,—sometimes only one, but generally two,—the cavity is allowed to remain only filled with a preparation of morphine and mastic, and after that the tooth is filled. In other cases I use camphor with mastic. But by this means I do accomplish what I believe no other dentist has done, and that is, to plug or fill the tooth cavity in the same sitting during which the pulp has been destroyed. This, however, depends upon the *complete absence of pain after the use of the electro-cautery*. I have already stated that there is always a little pain at the instant of cauterizing; but sometimes this at once disappears, and in such a case I do not hesitate to fill the teeth permanently. I also do this if there has been a little bleeding from the cavity of the tooth subsequent to cauterization. It might be supposed that this procedure of stopping the teeth so imme-

diately after the destruction of the nerve-pulp would be always followed by dull aching pain; but I am happy to say, that not the slightest indication of pain has in the great majority of instances ensued, in rather an extensive employment of this agent and method. As a *rule*, however, it is my opinion *the tooth should not be filled permanently on the same day that the electro-cautery has been applied*, unless in the instances just mentioned; that is, if the removal of the carious portion is not then being attended with sensibility. Experience and practice teach us to know the proper cases *which* can be filled at once or not.

"I have found by experience, also, that by waiting a day or two, any sensibility remaining after the destruction of the dental pulp and excavation of the carious parts of the affected tooth is sure to disappear, assisted by the solution of morphia and mastic, or mastic and camphor, which temporarily occupies the cavity. By this time the cavity will bear the pressure of an instrument within it, and an examination will show that the destroyed pulp has receded considerably inward; the black spot is now so out of the way that the filling will not press upon it, or, if it does, it becomes a matter of the smallest possible importance, so far as my experience permits me to judge in this respect. I must here, however, warn others not to mistake the *black speck* here referred to for actual remaining caries.

"Under the circumstances which have now been mentioned, the *results* of this operation are completely successful, and the teeth so treated are serviceable for years. If, however, tenderness of the tooth remain after the use of the cautery, it is always better to wait for its complete disappearance before proceeding to permanent filling. I cannot call to mind any single instance in which the pain was at all persistent after its use; but it will be sure to become so *if* the tooth is one not fairly suitable for preservation, from being either loose, or diseased at the apex or bottom of a fang, such as a small fungous growth, or some similar cause. In such cases, the destruction of the tooth-pulp, accomplished no matter by what method, will prove unavail-

ing and unsatisfactory. Extraction finally being done in such instances proves the only resource. Should there be associated inflammation of the gums with a carious tooth, in which the pulp has been destroyed in the manner which I here recommend, then the usual means for combating it must be resorted to, such as a leech or two applied to the gum, and repeated fomentations with warm water alone or warm milk and water, bran or hop poultice. For pain in the tooth itself, the morphine and mastic will be found quite sufficient."

Urinary Bladder and Renal Calculi.

Attempts have been repeatedly made to harmlessly dissolve *calculi* in the living urinary bladder. The first attempt appears to have been by Dr. Harle, of Norwich, England; but the first report of actual treatment for this by electricity is by MM. Provost and Dumas. These trials were with a view to destroying their state of aggregation; for if the molecules of the calculi become friable, they would wash out. But after experiments on dead men, and on living dogs, and becoming satisfied that their method was to a degree susceptible of application, they perceived that it can present no advantage for the removal of calculi that are not saline compounds, such as, for example, the alkaline phosphates. It is therefore necessary beforehand to be satisfied as to the *nature* of the calculi in the case, even if otherwise feasible. By a series of elegant experiments by M. Bonnet, surgeon-in-chief of the Hotel Dieu at Lyons, he has shown in a satisfactory manner that electric currents have the power to *convey* acids or alkalies *to* the urinary calculi by the electro-chemical decomposition of a saline solution that has been previously thrown into the bladder, as when using the solution of nitrate of potassium, instead of simple water, without the powerful reagents being diffused in the urine that is contained in the bladder. (See Appendix E, F, G.)

Dr. Bence Jones pursued these researches by means of the steady galvanic stream, and concludes that the solution of nitrate of potash is for most cases, and on the whole, the most harmless

to the viscus, and most active for the dissolving process. Calculi of the oxalate of lime are the only ones that have resisted this action, and these, if they contain phosphates also, are slaked down, but if they contain the urates, or uric acid, then they are slow to yield.

Notwithstanding all this, but few fair attempts have actually been made to dissolve renal calculi from the bladder in the living human patient. The results, on the whole, so far, I conceive, are negative; although it has been claimed by Dr. Melicher and others, as we are aware, to have been successfully accomplished. The calculi are probably only affected *secondarily*, even by the improved process, while the current is separating the nitric acid, and driving it to one pole, and the potash is hurried off to the other. Nor can the bladder play the part of an electric bath tub for such chemical power, without receiving some doubtful effects.

Dr. Simon has recently treated some cases of *incontinence of urine* in children by means of galvanism, the current being conveyed by the aid of a partly insulated catheter into the bladder. The result in two or three marked cases, he says, has been quite successful. The cases selected for this treatment, of course, are those of true *incontinence of urine* from *atony*, and not from irritable bladder, or from kidney or other urinary diseases.

A clear and practical distinction can and should always be made between the paralysis of the neck of the bladder and that form of paralysis that affects the body of that organ; the first form being attended with *incontinence* of urine, the second with *retention* of urine. But we hardly believe that this important difference is clearly attended to by very many practitioners.

According to Dr. Gross, of Philadelphia, and Professor of Surgery in the University of Louisville, *irritability* and *neuralgia* of the bladder have many points in common; indeed, few authors devote a distinct chapter to the latter affection. Neuralgic affections of this viscus, in our country at least, certainly seem very common; and according to Professor Gross, we may usually find neuralgic symptoms at the same time in other

parts of the patient. Sometimes the pain is located in one spot; at other times it extends to other organs. There is in these cases a frequent desire to pass water, and the urine is thrown out in jets, and in very small quantity, while a distressing soreness is left behind in the urinary passages. A systematic course of laxatives, together with morphia, or belladonna, or conium, seems usually beneficial; but the electric *positive* pole, directed *precisely* to the part affected, while the other pole is at a distance, and a gentle current is thus circulated for five or ten minutes, will all the better quell the neuralgia at this site. (See Appendix E, Notes 1, 3, and G, Note 4.)

But where the bladder is rather affected with *atony* or *paralysis*, instead of irritability or neuralgia, then the electric current must circulate in the opposite direction *mainly*, that is, to suddenly *reverse* the current, and make it for one minute this way, or *direct*, and but a quarter of a minute reversed. (See p. 338.)

In managing the various forms of paralysis of the urinary bladder, I cannot but urge the precaution laid down by Dr. Gross; and that is, where the accumulation of water is large, or has long existed, to never evacuate the whole of the urine at once, as he says he has seen several patients die from the severe depression induced by the *sudden* removal of the accumulation from such an over-distended bladder. In all such instances, he advises to allow a small quantity of urine to remain, and to apply a bandage to the abdomen, as after tapping or parturition; to give castor oil and turpentine cathartics, together with strychnine and tinct. cantharides.

Incontinence of urine may often be observed in patients who have had rheumatism. In most of these cases, the affection has been referred to some deviation in the spinal marrow. But Dr. Froriel denies this,—as any affection of the lower portion of the cord, which would cause paralysis of the bladder, would at the same time produce some paralytic symptoms on the voluntary muscles of the lower extremities. It is therefore referable rather to a local affection of the bladder itself—to some deranged state of *its* nerves, of its muscular fibre, or of both. Taking this view of the malady, he resolved to try the effects of the local

application of electricity; using a metallic stylet, insulated and terminating in a button-like point, which he introduced into the bladder: this he does with the aid of a gum-elastic catheter, that covers the whole except the button point. The handle of the stylet is then connected with one of the wires of an electro-magnetic machine, while the electrode of the other conductor is pressed against the pubes. Thus the induction current of electricity is passed through the bladder for a quarter of an hour each day. The result is, he says, that generally the bladder retains its urine better from the very first day after the application of electricity. But this should be repeated at intervals, until the bladder recovers its full power. He reports several cases of this trouble in persons from thirty to forty years of age, in whom the affection was completely removed by means of this form and method of using electricity.

Electricity is found equally capable of removing the weakness on which the enuresis of children depends. In some cases one such application of electricity removes the disease. In others it requires to be repeated at intervals. It is found that, in some weakly children, a few doses of iron confirm the cure. In connection with the electrical treatment, I usually prescribe in such cases one drachm of the muriated tincture of iron to seven drachms of simple sirup, to give the child a tea-spoonful at every meal. (See Appendix E, G.)

Hernia. — The *cause* of this difficulty we will not here discuss; but evidently, if the relaxed fibres of the abdominal muscles and fascia that are concerned in bounding the "*abdominal rings*" can actually be toned up to a natural state of *tonicity*, and if the due *peristaltic* movement of the intestines themselves can be reëstablished, we certainly shall have already proceeded far towards obliterating *that condition* where hernia is likely to recur. With this view we are to direct the electric influence to the patient, and particularly to the site of the "*weakness*." In treating these cases, we need to employ mostly the large metallic-ball electrode, covered with wash-leather, and to run the current *towards*, or through and through, the site of the rupture at one *seance*, and, through *from* the spine *to* all the abdominal

muscles and the underlying viscera at another, and then strong localized Faradaization at another, and so on. Very many cases can thus be cured. But where this fails, I would strongly recommend the *galvano-puncture*, or sparks *drawn* from the acupuncture needles, *for radical cure*, which I know can reach a large class. Then there is another class of cases, or rather portion of cases, (for I cannot define them,) which do not seem to be benefited, much less cured, by these means. When this is thoroughly performed, however, and if not *overdone*, we can testify from clinical experience, that in very many cases it wonderfully obliterates the hernia, or at least restores the *non-appearance* of it, even where the truss is no more worn. A cold, wet cloth or sponge but *instantly* wiped as a *shock* across the lower bowels and groins, night and morning, aids in confirming the muscle *tonicity*. (See Appendix F, G.)

Action of Narcotic Poisons.—Electricity as a Remedy.

There is evidently a *law of action*, definitely manifested by different poisons on the nervous system, whether generated in the body, or introduced into the body. The action of nicotine (the quintessence of tobacco) has lately been investigated by M. Claude Bernard, and he finds that mammalia, birds, and reptiles are all destroyed alike by nicotine under similar symptoms, and that whether taken by the stomach, or applied to a wound in the skin, or introduced into the eye. *The arterial capillary system was especially primarily affected through the medium of the sympathetic nerve.* Thus the circulation is arrested first in the capillaries, while the heart continues to pulsate. The veins are full, but they no longer convey the blood onward. It is therefore manifest that nicotine (tobacco) affects the nervous system *of organic* life, just as strychnia affects the nervous system of *animal life*. Convulsions may and do occur in either case, (though not necessarily so,) as among the most prominent symptoms. This is worthy of note, for it must go to show the influence of the sympathetic nerves on the vascular capillary vessels. Dr. Bernard states that he found the

modus operandi of this poison, when partially decomposed, (?) to be then quite different from that of pure nicotina; for the functions of the heart and lungs were *directly* affected by the latter; i. e., by the impure article; while the pure poison chiefly spent its physiological action on the *capillary* circulation alone. Besides, the pure article produced tetanic rigidity of the limbs, while the impure, though more largely given, did not. Nicotine (i. e. tobacco juice) may therefore be employed as a remedy for poison by strychnine; but it must be promptly and freely given, as the one poison neutralizes the other. I look upon the continuous current of galvanism applied to the spine, and nicotine as such, or as tobacco smoke or tea, administered by enemata, or otherwise, *as the only two direct anti-spasmodics known to the medical art.*

Again, it is found that opium and belladonna are mutually remedial; i. e., when either of them has entered the system in too large or poisonous dose. This has been suggested by Dr. Corrigan, and proved by Dr. Graves. It is shown that if these two articles are given together, sleep is not induced; but if given separately, their individual and peculiar effects are realized. Dr. Wharton Jones, in the course of his researches on the state of the blood and blood vessels in inflammation, found that an artery in the web of a frog's foot, under the microscope, was constricted in a varicose manner, almost to obliteration, from the application of a solution of the sulphate of atropia, (belladonna,) while at the same time the blood in the corresponding capillaries and venous radicles was in a state bordering on complete stagnation. The blood was but just flowing in the constricted artery, when he applied to it some of the *liquor opii sedativus*, and the effect was a prompt and full dilatation of the artery, and a brisk flow of blood. On the other hand, he found that arteries that had been dilated by the *liquor opii* applied to them, contracted again when that was washed away, and a solution of atropia applied in its place.

The fact is, the kidneys are not to "*form*" urine, but rather to take up and separate from the blood certain substances that have become useless or hurtful to the system. Dr. Bence

Jones says, "Any organ that is used must be repaired; and the substance that has been used must be removed. Take the muscles, for example: the muscles consist of water, salts, non-nitrogenous fat, and a highly compound arrangement of carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus. Carbonic acid, ammonia, water, sulphates, and phosphates are the last products of muscular action, and of the action of oxygen on the muscle. The intervening products, probably, are innumerable, as kreatine, kreatinine, uric acid, urea, and choleic acid. Some of the products are thrown out of the body by the lungs, others by the kidneys. If the removal of some of these products, which usually go by the lungs, is stopped, the circulation through the lungs ceases in two minutes! the heart and brain are stopped, and from the mechanical stoppage in the lungs death ensues. If the removal of these products by the kidneys is stopped, in two days the patient is poisoned; the nerves and muscles are affected by the poison, and *chemical* death ensues.

"If beef steaks (the *muscles* of an ox) are given to one who has taken strong exercise, and is in perfect health, they are dissolved, pass into the blood, and their chief use is to *repair* the human muscles and nerves, not to form excrements from the bowels, uric acid, and urea, and the constituents of the urine. The *waste* of the muscles and other organs *passes off* in the urine, whilst the food nourishes the wasting organs. Such are the clearest ideas I can give of the urine in relation to the system and the food, and theoretically I consider this as the true healthy relation; and perhaps in a state of full bodily labor, (i. e., when enough food, and no more food than enough, is taken,) this may be the only relation; but provision has been made for too little labor and for too much food. If too much food is constantly taken, and too little exercise, plethora, hemorrhage, and humors must take place, if some escape for this excess be not provided. We know that the phosphates, sulphates, and urates are generally increased in the urine after food has been taken. If more food is taken than is required for the absolute wants of the system, then the *excess* is thrown out by the same organs that remove the waste of muscles and

other structures. If even excess of water alone is taken, the excess is thrown out, partly at least, by endosmotic laws, not yet clearly defined or applied. How the quantity of substances to be thrown out is determined, I do not yet distinctly see. As far as I can understand, it only adds to the difficulty, to say that the *un*vitalized portion of the food or water is thrown out, whilst that portion which *is* vitalized, remains in the blood. Where, and why, uric acid is formed directly from the food, seem to me questions more likely to be solved by keeping them distinct from questions of vitalizations." Long ago, Dr. Prout most fully recognized the fact that the food not only nourishes the body, but, when an excess of it is taken, it passes off, in part at least, in the urine. That this *double* relation of the urine exists, I have also proved to myself, in opposition to the theories I had formed. The facts, then, are these: food makes blood; blood makes muscle; this, when used, returns in a different form into the blood again, and passes out by the *breath* and *urine*. This is the first and most healthy systemic or larger circle. The second less healthy relation is caused by *excess* of food, or *diminished* wants of the system, as from various causes. This circle is smaller. The excess passes directly into the blood from the stomach, and passes out by the breath and urine.

Dr. Jones then, in conclusion, says, "I will rapidly run over the general mode of proceeding in an ordinary examination of the urine. The urine cannot be well seen unless in a transparent vessel. A six-ounce vial, filled with the urine, and sediment, if there be any, will be sufficient for every purpose. If possible, the urine should be put into the bottle as soon as it is passed. The first test to be used is litmus paper. The question you ask is, What is the state as regards *acidity*, not as to the quality only, but as to the quantity? Is it too much or too little acid? Litmus paper cannot fully answer this question. It *can* tell whether the urine is ammoniacal, or alkaline from fixed alkali, or contains little or much acid, but it *cannot* tell whether the acidity is more than it should be. Simple inspection of the urine is able to solve this question, and that better than any other mode whatever. There cannot be an excess of

free acid in the urine without the uric acid being set free, though this often requires many hours to crystallize out. If, then, you wish to know if the urine is too acid, you must leave the vial at rest for twenty-four, and sometimes ninety-six hours, and if there be too much acid, *red crystals* of uric acid *will be* very distinctly *seen* adhering to its sides, or deposited. The microscope may tell you quicker, but it will not tell you more surely, than the naked eye. Whatever the degree of reddening of the litmus, or the amount of urate-of-ammonia sediment, you cannot with truth speak positively of excess of acid being present, unless you *see* uric acid crystals; and it is only when *free* acid is present in the urine that alkaline remedies are absolutely necessary."

In taking a sample of urine for test, I would here add, it had better be of that made early in the morning, and it should be passed altogether as usual in the ordinary cabinet (chamber) vessel, and then stirred, so as to mix the whole, just before pouring it into the clean vial; and this should be done immediately after its passage by the patient.

Perhaps it would not be amiss to add, in this connection, a condensed *philosophic view of the phenomena of inflammation*, as given by Dr. R. Billings, much in these words: "The contraction of the heart is *muscular;* that of the arteries is *elastic.* The *heart contracts* and *relaxes alternately;* the *arteries*, on the contrary, keep up, by their contractile tissue, a constant *contractile* or elastic pressure on their contents; not, as has been commonly supposed, an alternate contraction and relaxation, but a *continued* contractile effort, both longitudinally and transversely, which is overcome by the action of the heart. When there is much blood sent into them, they are distended; and if there be little blood sent into them, as after hemorrhage, their tendency to contract causes them to close, so as to keep always full, and to preserve a continuous stream of blood, even during the temporary relaxation of the heart; and the arteries yielding and adapting themselves to the pressure of the heart, and recontracting on their contents, whilst the heart is relaxed and filling, is the cause of the equability of the stream in the veins.

It is necessary here to state distinctly my opinion respecting *action*, as depending on the nerves. I consider that the *muscles* and *capillary arteries*, though *differing* in tissue, have each, inherent in their structures, a faculty of contracting, which is *organic* contractility; this *contractility* being *acted upon* by the *nervous influence*, and the *result* is *contraction;* the nervous influence being discharged into them from the nerves.

A variety of circumstances leads us to the conclusion that the nervous influence is analogous to, or depending upon, if not identical with, the electrical principle or fluid, whatever that be. It is very common to say that, in inflammation, there is an *increase* of arterial action; but a consideration of the phenomena, and of the nature of arterial action, will show that, in inflamed parts, the capillary arteries are *weaker* in their action; that there is *diminished* arterial action, for the action of arteries is contraction. Now, the arteries in inflamed parts are evidently larger than before — less contracted, that is, acting less.

The way to diminish inflammation, therefore, is to increase the action of the arteries; as by cold, for instance, which makes them contract; i. e., *increase* their action. It is common to speak of the *throbbing* of the carotid arteries as increased action; but the more they throb, it shows that they the *more yield* to the injecting force of the heart. As the heart therefore acts against the capillaries, if we cannot cause them to contract strongly enough to resist its force, we are obliged to diminish the force of the circulation, either by taking away blood, which decreases both the quantity of blood sent to the arteries, and the action of the heart itself; and in this way we leave less for the arteries of the inflamed part to do; or we can lower the *force of the heart* by medicines, such as digitalis, veratrium, &c.

Dr. Graves remarks that physicians have been too much in the habit of regarding all cerebral symptoms, in fevers particularly, as the result of congestion, of inflammation, or of a derangement of the balance between the venous and the arterial systems of

vessels. Instead of this being always the fact, probably many of these symptoms arise from causes altogether different, which, judging by the effects produced, bear a close resemblance to *poisons*. For example, there is a common idea "that in acute cerebral affections *dilatation* of the pupil only attends the state of coma or insensibility, and that, on the other hand, *contraction* of the pupil is always associated with a morbidly 'active' state of the sensorium." This opinion, he thinks, is shown to be erroneous by his attentive observations of the pupil in a succession of fever cases; and also by the fact that poisoning with a certain species of mushroom produces contracted pupils during the stage of perfect insensibility, but widely-dilated pupils, during the fury of delirium. The coma with contracted pupils, that may be caused by opium, he thinks can always be relieved by belladonna, if timely given; that the sub-cutaneous injection of morphia will cure one class of neuralgic seated pains, while it is only atrophia thus used that will reach another class, i. e., *where morphia fails;* that in case either should act unexpectedly, too profoundly, the other will neutralize it. But I must here add as a precaution, not to venture too much in trying the sub-cutaneous injection of so powerful an agent as atrophia.

The following case of *laudanum poisoning*, treated with electricity by Dr. Russel, house physician of King's College Hospital, shows the value of this agent as an excitor of the great nervous centres: Mary Ann H., aged two months, had taken, through a mistake, some twelve drops of laudanum. The medicine had produced deep sleep, and in the space of two hours, convulsive movements of the extremities. When admitted, the infant was quite insensible and as motionless. The surface was cold and exsanguine; the impulse of the heart could not be made out. Breathing was very difficult, and was performed with intervals of half a minute, at least, between the inspirations. The pupils were very small, and she had lost the power of swallowing. The usual remedies had been employed without success, and in a quarter of an hour more, the child appeared to be quite dead; but while being removed, she was heard to rattle in her throat,

and to breathe once more very deeply. This encouraged to a new attempt at restoration. The magneto-electric machine was quickly employed, one pole being placed over the upper part of the cervical region of the spine, and the other over the ensiform cartilage of the sternum. The greatest benefit resulted immediately. Rapid action of the diaphragm followed each application of the poles. A few short inspirations having been induced, were followed by a deep breath. At this time, five hours and a half had elapsed since the accidental administration of the laudanum. The last remedy — the electric current — was persevered in for an hour and a half, shocks being passed through the chest and along the course of the spinal column, whenever the breathing flagged. At first this stimulus appeared to influence the diaphragm alone; but in a short time the arms were extended; and soon afterwards the legs also, whenever the poles of the magneto-electric machine were applied to the surface of the body. The child soon opened her eyes, and seemed to notice surrounding objects; she then uttered some cries, and the surface became warm. The head no longer sank on the shoulders, but was self-sustained. In about eight hours and a half after the laudanum had been taken, respiration became reëstablished, though not yet with regularity; but the further use of electricity was not required.

Chloroform has been of late much employed* for procuring sleep in those cases where opium is contra-indicated, or fails to act. It is administered in doses of ten to thirty drops, suspended in a little gum-water, or some other mucilaginous fluid, and given at night. It generally succeeds in such cases in procuring for the patient two or three hours of tranquil sleep. In this way it has been much used in cases of old bronchitis, attended with profuse secretion, also in *hemicrania*, and in other painful nervous affections, where opiates have lost all power of alleviating the patient's misery. In any such case, if the chloroform should act too powerfully, electricity is the remedy.

There is a case of poisoning by laudanum related, which occurred in the Middlesex Hospital, and which was ultimately

* British Medical Journal, April, 1858, p. 328.

treated, as a *dernier* resort, by electricity. After the stomach pump, flagellation, and a multitude of other inhuman and yet ineffectual means, he was aroused finally by means of electro-magnetism and static electricity. "The pulse soon became more steady, firm, and frequent; the respiration more indicative of resuscitation. The powerful 'electrical machine' was also got into full play before a large fire, and the jar was filled and discharged, when some brilliant sparks and strong shocks were occasionally also passed *through his head*, spine, thorax, and abdomen. The result of this was, that the man soon opened his eyes, and his mouth, too, for he abused the operators for a pack of rascals who were 'trying specimens' on him. But incomparably the most satisfactory effect was produced by giving him a shock (from the Leyden jar) *on the tip of his nose.* To use a phrase of the ring, he *rallied* wonderfully under this" — a hint worth taking and retaining, for the nose is exquisitely susceptible to all electrical influence. It is probably the most vulnerable point in the whole human body, in all forms of suspended animation, for applying *strong* induction currents.

A very interesting case is related by Dr. M. Barry, of an infant aged nine months, which had been poisoned by thirty drops of laudanum, and was not seen till seven hours afterwards, when in a state of profound *coma.* From this state it was aroused by the employment of electro-magnetism. At first, when the current ceased for a moment, the child sank into a profound sleep, and there was no marked amendment until the means had been continued for three hours; four hours and three quarters passed before it was thought proper to discontinue its use. The child, however, then recovered without any further head symptoms.

Dr. T. P. James gives a case of resuscitation by the primary current of electricity, after poisoning from an ounce of *tr. opii.*, which is thus related in the Lancet of June 19th: —

When the sponge electrodes were applied for a few minutes, no sensible effect was produced; but soon afterwards the muscles of the neck began to quiver, when sensibility appeared gradually to return, and after twenty or thirty minutes the stim-

ulus produced undoubted discomfort, as evinced by shrugging of the shoulders, and attempts to avoid contact with the sponge electrodes; but the first marked influence of its effect was the ejection of a large quantity of fluid from the stomach. In another hour she appeared quite lively; answered questions distinctly, and in a moderately loud tone, though in a somewhat peevish manner. The galvanism was occasionally intermitted for a few moments, when she relapsed almost instantaneously, and "dropped off" in the midst of a sentence which she had commenced during the application of the stimulus.

The pupils remained unaffected till about two hours had elapsed, when they became somewhat more dilated, and sensible to a strong light. All the symptoms gradually diminished, but it was absolutely necessary to reapply it, at longer intervals, until half past five P. M., when she seemed so far recovered as to allow of her removal to the ward. From the easy diffusibility and quick propagation of the galvanic fluid over the whole system, irritation, capable of exciting action almost *ad libitum*, can be applied to any part, or even the whole of the body at one time, and that of a nature void of all the unpleasant results which necessarily follow bastinadoing, cold affusions, searing, the *dolichos pruriens*, and a whole catalogue of equally brutal resources, which, for the safety of the patient, have necessarily been had recourse to, before galvanism was resorted to. By dipping the wet sponges of the electrodes into moistened salt, it assisted the passage of the current and increased the conducting power of the electrodes, or rather *overcame the resistance of the skin*, to a striking degree. In ordinary cases, where the primary current of galvanism is used, the application, if strong, reddens the skin, and may even produce some tumefaction, which remains often for hours. But in this instance, although the current was probably three or four times as strong as is generally used, not the slightest discoloration was observable. It should be noticed that as soon as she was allowed to fall off into a deep sleep, (which she was occasionally permitted to do, after the extraordinary influence of the battery was fully proved, so as to be relied upon, in rousing her instantly from the deepest narcotism

to a fretful impatience,) then the pulse gradually lowered in its power, became slower in its action, and irregular in its movements; but no sooner was this remarkable stimulus laid on again, from time to time, than the pulse rallied — was regular, fuller, and quicker; and the respiration, that was previously labored, slow, and unequal, now became more frequent and deeper. The countenance also evidenced, in a striking manner, the singular influence of this agent. When she was admitted, the cheeks were of a leaden hue, and the lips of a tawny color; but after the expiration of one hour, with the use of the galvanic compound battery, they resumed a somewhat natural tint. The patient completely recovered.

Dr. W. Braithewaite, of the Leeds school of medicine, the author and editor of "Braithewaite's Retrospect," says, "Recent observations show the wonderful efficacy of electricity in some cases of poisoning, and will confirm the remarks made in former numbers on the efficacy of electricity in arousing the patient from his stupor, when under the influence of opium. An electro-magnetic apparatus ought now to be in the possession of every practitioner of medicine.

"In the extreme case of opium poisoning referred to, where all ordinary means had failed, cerebral congestion was urged as then offering an objection to its use, but admitted not to be sufficient, in such a desperate case, to set aside the trial of it. It was immediately put in use, and with the happiest result. With an assistant rapidly rotating the wheel, the ball electrodes were applied at first to each side of the neck, and then moved along down behind the clavicles. The arms and body were at once moved convulsively by it, but the patient lay as unconscious as before. One electrode was then passed *over* the region of the heart, and the other to a corresponding point on the right side. In an instant, his eyes opened widely, and with a ghastly expression of countenance, his head and body were thrown one side convulsively, and he groaned. He now sank back into his reclining posture, and was again instantly asleep. The balls were reapplied in the same manner and situation, with similar results, for several times. Reaction was soon positively estab-

lished; the heart had received a sufficiently strong impulse; the pulse was becoming rapidly developed, and the whole surface warmer. They desisted, and watched him attentively, allowing him to remain quiet for an hour. Reaction continued satisfactory, and when the hour had expired, he could be awakened by shaking him and calling his name loudly. There was no further occasion for the battery." (But this must have been no battery, but rather a magneto-electric machine, which indeed answers the very best of purposes in such a case.) The writer says further, —

"Before closing this subject, I would add, that electro-magnetism will be found highly useful in some forms of disease, particularly those of a *congestive character*, *where oppression of the organs*, *and of the nervous system particularly*, *prevents reaction*, *and thus speedily destroys life*. In practice, I think we frequently see cases where death seems to occur by an *obstruction*, (or *cessation of action*) of the functions, or of those imperative organic movements which support life, more than by any absolute exhaustion of the organic functions, or of life itself. In such cases, the Faradaic currents of electro-magnetism, or magneto-electricity, might communicate an *impulse* which would renew those sympathetic actions between the organs (if no positive lesion) upon which the *continuance* of life depends." (See Appendix F, Note 1.)

In all cases of *asphyxia*, electro-magnetism must be useful; and I believe it can be applied in many instances to stillborn children with the happiest effects. The author has used it thus, and would add that only a low degree of current should be so employed.

Wall-Paper Poison.

This is, we believe, a prodigious source of ill health, and doubtless frequently *helps on* some of the graver nervous affections, and even the "*decline*." The poison from bright or velvety green paper-hangings (with green ground, or *merely green vines or figures*) is more frequently an *arsenic poison*, (the dark English green, and the blue, are more likely an oxide of

arsenic and copper; the bright yellow and white are of lead, and the olive green from arsenic, cobalt, &c.,) while the poison from water service pipes we know is a *lead poison.* But mark! these two classes of very deleterious agents — in effect, "*slow poisons*" — are actually and perpetually at work, contaminating almost every respectable dwelling in all our large cities, as well as the majority of country residences and village homes. Arsenic acts as an *irritant* poison, while lead acts as a *sedative* poison; but from the *ultimate* effects of both (or either) there may occur pains, palsies, weaknesses, and emaciation. But physiology shows us that there is a ceaseless depurating and *repairing force* going on in the human organism during health, which indeed is a very law of our being. Therefore, while the poison is minute on the one hand, and, at the same time, the health of the individual is vigorous, nothing of it is perceptible to us, although some of the organs may already feel the insidious influence. Now, if the vitality of any member of the family become lowered, from any cause, and consequently the depurating and repairing force is enfeebled or nil, and particularly if, at the same time, the minute particles or portions of this poison be somewhat increased, then it is that the nervous system gives way, and finally becomes deranged and diseased. The more immediate effects and consequences of extremely minute particles of arsenic floating in the air, or as dust, in the rooms of a house, it must be known, *do not act the same* as when arsenic is properly prepared and taken as a medicine, but appear to be manifested by a weakness, or a kind of irritation of the eyes and throat. Dr. Jeffries recently read a very interesting paper on this subject before the Suffolk District Medical Society, showing that there may also be *sudden* and unaccountable attacks of *dyspepsia*, and other gastric derangement. Next, we find there are pains, partial palsy, loss of flesh and strength, and the case may possibly be mistaken for that of consumption, and then the end is inevitable.

As a member of the medical profession, peculiarly positioned for seeing and knowing these direful consequences of *house poison*, I feel it a *duty* thus to plainly speak and urge the

information of the public mind, and, if possible, to arouse the attention of the public authorities when it becomes more generally known. Already in Germany, and, I am informed, in France also, recent laws have been enacted prohibiting the hanging of arsenical and other poisonous wall papers; and this perhaps may account for the cheapness of those beautiful but baneful French papers, of flock green, and velvet green with gold, that have of late flooded the American market. Is it to be wondered at, that a refined people should become more or less enfeebled, nervous, and scrofulous, and suffer much from deranged health, when the "*home*" itself, from very childhood, is so contaminated with deleterious agents? We get poison (though minutely, it is true, and perhaps but rarely) through the copper culinary utensils; poisonous carbonic acid gas in prodigous volumes emanate from the gas-burner in the sleeping chamber, or from the multiple chandelier in the drawing room, and more frequently from both, and so pervades the halls and apartments of the whole house during all the night hours; and too frequently the furnace is likewise leaking sulphurous and hydrogen gas, (imperceptibly, perhaps, or even actually perceptibly by the senses,) thus saturating all articles and apartments, from dining room to attic, day and night; and besides this, there is almost always *a very disturbed electrical state of the warmed air*, that pours in like a ceaseless river, but not a pure atmosphere, it having first passed over the surfaces of sundry hot irons in the "*improved*" hot-air chamber of the furnace, and so supplying the house with warmed air. Pandora's box! — no, I will not compare, for Hesiod says Pandora closed the lid of that fatal box before *Hope* could escape; but here we do still hope that these "improvements" and "*comforts*" of our day will yet be corrected. We are not yet all dead who remember in childhood the pure whitewashed walls and clean floors, the large open fireplace with the winter evening's blazing fire, and tallow candles. Those rooms were light, and those families were healthy and happy.

But to resume: It is, I believe, much owing to the electrical changes in the dry air of the apartment, that the im-

palpable powder of free arsenic becomes detached from the surface of the room-paper, and it is dampness that precipitates it with the dust upon all articles; so also the moisture of the throat prevents it reaching the lungs. But may it not be that the hydrogen from the furnace, soil, or other sources, combining with the arsenic from the wall-paper, forms arsenical hydrogen, and so acts virulently? for this is one of the most intensified and deadly poisons known. Therefore papers with green are to be discarded. All wall-papers should be *glazed*, or the walls *painted*. *Service pipes for water should be of iron;* and he is a public benefactor who will render iron pipes as available for the purpose as are pipes of lead.

MEDICAL STUDENTS: Our investigations in this so intensely interesting field of medical lore, must now draw to a close. Let us here congratulate ourselves, and thank God "for this day and opportunity" of seeing *understandingly* so much of this *new phase* of our noble art. I said to you in the Preface, that we were rich in the material for a systematic work of this kind, and now can say again, that we feel still burdened with the untold matter that so interests ourselves, and which we desire you should know. But the original bounds of this work are already far exceeded; I therefore will only remind you, with a parting emphasis, of the beautiful aphorism of Dr. Althaus, (who, by the way, has written well on this subject,) that "it is not electricity that cures diseases, *but the physician*, who may cure disease *by means* of electricity." In a word, it is the *method* and *skill* directing this agent, that give the success.

APPENDIX.

Directions for operating about the Face and Head with Electric Currents.

D. Note 1. (For notes under A, B, C, see page 475; see also 334, 395.) For "*tic douloureux*," i. e. after correcting the faulty function, or whatever is the provoking cause,—so also for *rheumatic face-ache*, periosteal jaw or teeth-ache, earache, for diffused hyperæsthesia, or peripheral neuralgia, &c.,—the best method to be pursued in these cases is, to begin by placing the *negative* sponge electrode down inside the loosened dress to the pit of the stomach, or better still if to the lower umbilical region; then with the *positive*, a fine moist sponge, conveying the most gentle or even imperceptible current, and if electro-magnetic, let it be of the finest vibrations possible,—thus commencing on the side of the neck, gliding it about there thoroughly, then along up to, and a little in front of, the ear, and then on to the face, by wiping it over as if washing; then work back again to the neck, and now gradually increase the current while there, lingering some at and about the exit of the *portio dura;* then working the sponge along upon the face again, with the stronger current, by gliding and hitching motions,—say every quarter minute,—and thus for some 5 minutes, lingering mostly about or over the most painful spots. If there is then still any decidedly painful or tender spot left, choose a smaller sponge-tipped electrode *positive*, and plant it moderately firm *directly on the site of pain or soreness*, which is most likely to be found at the *supra-orbital* or *infra-orbital* nerve exit, and retain it there for 3 to 5 minutes, with all bearable current,—be it more or less,—until the pain and soreness are completely chased away. Always avoid touching the forehead with an electrode, because the periosteum of the bone is so near the skin that more pain is produced than relieved. I usually finish such a *seance* by wiping the larger sponge electrode again a few times over that side of the face and closed eyelids, and then passing it on to the side of the neck for the last minute. Now, if the pain returns at any time within 6 hours, repeat the treatment. If it does not return within that time, it is probably cured. But if it persistently returns, time after time, in spite of this treatment, you in all probability have not corrected the functional or habitual *cause*, or else you have in that case organic disease.

D. NOTE 2. (See pages 336, 369, 380, 396.) My experience in the treatment of *cephalalgia*, or *head-pains*, and the various "*ugly and disagreeable feelings in the head*," those that occur *at the back of the head and neck*, arising from what I conceive to be *a "disguised" neuralgic condition of the ganglionic nerves in the head, or of the occipital nerves*, (but sometimes from this unrecognized condition of the *supra-orbital* nerve,) leads me to advise, as a general rule, to first pass the large sponge *negative* electrode well down the back, inside the loosened clothing, or else up under the clothing from below, so as to be beyond the cervical ganglia; and if as low as the *cauda equina* (second lumbar) is better still; then with the other large moist sponge *positive* electrode, commence over the cervical region, increasing the current to all that is bearable, (painless,) and thus wiping over the whole *sides* and back of the neck, slowly back and forth, without much rest, as far as to the shoulders, for some few minutes; then resting it from half minute to half minute, at or just below the most sore or sensitive places, at the base of the head, close to the hair, back of the ears, and on the posterior edge of the *sterno-cleido mastoideus* muscles. If the person is not nervous, and the first few *seances* do not better the case decidedly, then for once apply at a future sitting the large sponge *positive* electrode, and only a very gentle current, *to the crown of the head*, and upon the *parietal* protuberances, through the parted hair, where the spots must also be a little wet; retain this current and site of electrode some 2 or 3 minutes only, *well back* upon the top of the head. Moreover, sometimes change the site of the *negative* electrode *to the epigastric region*, while directing the small sponge *positive* to the *supra-orbital* nerve exit; also while more strongly bathing the neck and shoulders as before; *but never while the positive electrode is on the top of the head.* In this latter case—a procedure I seldom resort to—the *negative* must be somewhere down the back.

D. NOTE 3. (See pages 336, 534, 538.) *For operations about the eyes with electricity*, for "*heaviness*," *weakness*, premature "*poor sight*," or *paralysis* of eyelids, or for partial *amaurosis*, &c., we must proceed very differently from the method laid down in Note 1. Here, we have diminished nervous action; there, was exalted nervous action. True, I usually commence the *seance* by placing one electrode first at the epigastrium, and then at the lower cervical back, and with the other medium-sized sponge begin wiping over the closed eyes, face, and temples repeatedly, but as carefully avoiding the forehead; first with this electrode as *positive*, while searching for pain, tenderness, and the *bearableness* of the case; then with it as *negative*, for a minute or so longer; and if the current is electro-magnetic, let it be gently increased as strong as can be used, without producing pain or any kind of suffering. For some cases, both the electrodes can be applied to the eyes, and exchanged back and forth, with good effects, in working up the nervous tone and muscular response. This may become still more effective by reversing the current by the *switch* or *pole-changer*, instead of exchanging the site of the electrodes. Next we are to exchange the large or medium sponges for the more delicate

ivory electrodes, whose pea-sized sponge *tips* are wet with clean water only. These are to be placed — the one at the outer and the other at the inner angle of the closed eye, above or below, so that the current may traverse the nerve branches that ramify the *orbicularis palpebrarum*, as well as the fibres of that muscle, and the eyelids, and other tunics and glands about the eye, *when the electrodes are held lightly ;* or through the deeper parts, and the eyeball itself, *when these electrodes are more firmly pressed, so as to embrace the globe between the poles.* This effect is still more profound, if they are planted firmly at the outer corner of each eye, and the current is suddenly reversed; and still more so, if the positive electrode, a large sponge, is placed at the back of the neck, while the other, a smaller sponge, is pressed upon the eyeball, so that the current passes through the closed eyelids ; and this is still greater, if the current is occasionally — say every quarter minute — suddenly broken and *reversed*, for a second or so, but *maintained mostly so as to run from the nucha to the eye*, thus producing true ganglionic reflex action.

E. Note 1. (See pages 338, 398.) *Operations about the genital organs.* For *Faradaizing* the rectum, urethra, bladder, vagina, or uterus, as required for cases of *atony*, or weakness, for *prolapsus*, *enuresis*, local palsy, &c., we may employ long, slim, insulated silver, or glass, or gutta percha electrodes, with sponge or silver tips, made expressly for these purposes, and which, for such cases, must be connected with the *negative* pole. (See page 680.) The other, *positive* pole, may be a moist sponge, which, with a moderately brisk current that is often intermitted, and occasionally but for a moment *reversed*, (see notes on page 282,) is to be moved, every quarter or half minute, up or down the back, in short stages, and in an elliptical order, (see Notes F.,) i. e. up one side of the spine, and down the other; then *vice versa*, and so over the roots of all the spinal nerves, *and their respective ganglia ;* and finally along the sides of the body, and over the abdomen, during this part of the *seance*. Next, exchange the *internal* electrode for a surface sponge electrode, still *negative*, and by bringing the two near together, make them to promenade up and down the back a few times, with quite a strong direct current; then move them in small double circles over spine and back muscles; then, leaving the *positive* at rest on the back, or rather now and then moving it a little, proceed with the *negative* to bathe over the lower bowels, with very sharp currents, for some time, and so finish this *seance*. I should have said that this latter procedure has been my most successful method for *atonic Amenorrhœa*.

E. Note 2. When the aid of electricity is resorted to in midwifery practice, as it is and can be most judiciously and effectively performed any where, and by any earnest practitioner; for instance, as for those cases where "the waters have broke," and hours have elapsed, and yet, notwithstanding the hot tea, the *room promenade*, and a well-dilated *os uteri*, still the labor does not set in in earnest; or where the pains have been for some considerable time "*grinding*" and unavailing, the harassed patient and every one else is being "*worn out*," and yet the labor has scarcely progressed; also in those cases of

tedious labor, just as the moments arrive when it becomes evident that the powers of the patient must soon fail, or be speedily and effectively aided by this force of nature, (electricity,) or else by ergot or instruments, or by all these, and more; so, moreover, in *post partum "flooding,"* when occasioned by *atony,* want of vitality, or excessive fatigue of the womb and abdominal muscles; thus, wherever it is desirable to promote tone and *true "labor-pains,"* let the woman lie upon her side, while the operator, with a *brisk working* electric machine, (electro-magnetic, or magneto-electric,) takes his position with a large sponge electrode in each hand; the one, *positive,* is passed to the upper spine, from whence it is to be diligently moved about over the whole back and ribs, sides and breasts, while the other, *negative,* is directed to the abdomen; and thus with the two, separately performing the double circle movements simultaneously, (see Notes F. and E.,) the one on the back and thorax, the other over the abdomen; which latter is to be moved in short stages, and so swept well about the gravid uterus—*not continuously,* but from half minute to half minute—for some three or four such moves, (or until a true pain is induced,) and then give a recess of a half minute or so; and then repeat it in like manner, and so on, again and again, until true *labor-pains* are established, or the desired object is obtained. Sometimes the electrodes may be placed to advantage, so as to embrace the projecting abdomen transversely, obliquely, &c., for a little, but mostly as just advised. Sometimes it is important to trust one—say the electrode on the back—to the hands of the nurse, that the accoucheur may have one hand free. Where there is *no contra-indication,* the effects of the already strong current is greatly increased here, by a *sudden, occasional, and momentary stopping and reversing the current.* (See page 478.)

E. NOTE 3. *Not so* must we proceed, if the affection, on the contrary, is a *painful, irritable,* and probably a rheumatic, or a neuralgic one; for then we must invariably connect the abdominal, or *internal* instrument (electrode) with the *positive* pole, while the *negative* sponge is now directed to the terminal twigs of the femoro-crural nerve, on the inner side of the knee joint,—first on one, and then on the other; also moving this one about occasionally upon the thigh muscles, but without shock,—i. e. without producing a break in the current,—although it is well to vary its strength during the *sitting.* Neither is it always necessary to resort to the internal electrode for these cases. Indeed, I think I can safely state, that in the great majority of cases the treatment has been completely successful, where it was conducted with *only* the large moist sponge electrodes, the *positive* of which was directed to and about the lumbar region, the crest of the ilium, to the abdominal ring, groins, and thighs, and so terminating each *seance* while working both electrodes as low as the knees or ankles. Thus we are enabled to employ a very much stronger current, and also spare the moral feelings of the patient. Therefore I would further say, that for pains, weakness, *"ugly feelings in the small of the back,"* or on the sacral bones; for neuralgia of the spermatic

cord, testicle, scrotum, bladder, &c., in the male; or of the fundament, labia of the vulva, urethra, vagina, uterus, or ovary, in the female; as also for neuralgic lumbago, and for *dismenorrhœa*, (see page 398,) we are to commence the treatment by placing the *negative* electrode low down on the inner side of the thigh or knee, while with the *positive*, directed to the *cauda equina*, (second lumbar,) we perform circle movements on and about that part of the back for a minute or so; then removing the *negative* to the outer side of the thigh, and increasing the current, glide the *positive* up and down the whole back, about the loins and abdomen, until all pain, tenderness, and lameness are entirely wiped away. Next, return the *negative* to the inner side of the thigh again; and now pass the *positive* over and below the crest of the ilium and lower flanks of the abdomen, — lingering or working most, near, about, and over the most painful or tender spots, with a lively current, but not so as to cause much pain. Next, work it on the groin, inner and upper part of the thigh, and so on downwards, cautiously watching for any expression of new-caused pain; for this must be avoided. If, after several such treatments, there is obtained no substantial relief, then, perhaps, we are justified in also entering the private organs with suitable electrodes. This should certainly be done in the more obstinate cases. But I maintain that we may very much more frequently succeed without this last resort. This is peculiarly true as regards *amenorrhœa*, under Rule 1; and of *dismenorrhœa*, under Rule 2.

F. NOTE 1. (See page 383.) *Circle Treatments.* — Some of my most valued and frequently resorted to *methods* of manipulating the electrodes are termed the circle movements. These are performed, for specific ends, in several different ways: first, by the *single circle* movement, — i. e., usually done by one electrode, while the other remains stationary, — the *positive* being planted in the centre of the circle-making *negative*, or else situated more or less distant, according to the anatomy and the affection; or by *double circle* movements, — i. e., both electrodes are moved in circles, — the *positive* in a small circle *within* the larger circle of the *negative*, as if about a common centre; or by *alternate circle* movements on separate parts; or by *simultaneous circle* movements, — as for instance, where one, *positive*, electrode is on the back, while the other, *negative*, is on the stomach or bowels, performing smaller or larger circles there, and alternately, or at the same time, the former is moving elliptically up and down the back, or over a portion of it. Thus it is seen they accomplish specific purposes, and for the given case one cannot be substituted for the other; besides, we are thus enabled to very surely bring under the searching influence of such gliding and gently varying — although pretty smart electric current — all the muscle-fibres, through and together with the nerve trunks and their depending branches, as each becomes successively embraced between the two relatively changing electrodes, or as they receive the influence — within or beyond — of the sweeping electric radius.

There is another *double circle and seesaw method with team-electrodes*, that we often employ, as in Faradaization; as for *dermatalgia*, or neuralgia of the

skin, and for hyperæsthesia of the sentient nerves. For this the electrode must be small, and the electro-magnetic current must be as sharp as the patient can possibly bear. (See G., Note 5.) *Team-electrodes* is merely a term I employ to signify that mode of holding and moving two small electrodes in the same hand, with only a finger or two between them, as first performed and described by Dr. Duchenne, in his *localized Faradaization.*

F. NOTE 2. (See pages 377, 381.) *The General Tonic, or Vitalizing Seance.* — This was instituted by me at first only for cases of general debility, incipient decline with weak chest muscles, and nervous cough; for emaciated children, and young persons with cold skin and poor circulation, as after severe sickness, and for *general hysteria.* But the past year or two I have found it also *the treatment* for rachalgia, "*irritable spine,*" rheumatism of the vertebræ, and hyperæsthesia of the back muscles, as well as for atony of the abdominal viscera, for constipation, &c. (See *law* of electro-physiological action, on page 477.) The patient is seated upon the ottoman or stool, and the operator takes his seat behind him. The *negative* electrode sponge is first directed to the umbilicus, or, if a female, to the left ovary or colon, while the *positive* moist sponge is firmly held, and slowly glided over the whole back, shoulders, and thorax, for a few minutes; then increasing the current still more, (*more* in proportion as the patient is *less* nervous,) carefully, but considerably, and now moving the two electrodes all the while in less or greater circles, the one on the back, shoulders, or thorax, the other on the abdomen or thighs, and otherwise modified to the case, — *but always observing the same relative current direction,* — thus *depolarizing* the roots of the spinal nerves when exalted, and arousing the peripheric nervelets when diminished, and calming or "*modifying*" the great chain of ganglia in the sympathetic department of nerves! Now, the evidence that this or its equivalent is obtained, — whatever it may be termed, — is the almost uniform fact, that after such repeated sittings, either alone, or as aid, or aided by other judicious medication, the ovaries are found not so sensitive, and the catamenia flows more promptly and easy; the bowels are not so tardy, muscular tone is awakened in the abdominal parietes, — i. e., there is not that baggy sensation, or constricted condition of the abdomen and its contents, — digestion (and secretion?) is invigorated, and there is evidence that the muscles of the back and sides, as well as the vertebræ and ribs, are less sore, less tender to touch or pressure, and the whole body and limbs are less lame, and not so "*tired;*" and if there has been hysterical or hypochondriacal manifestations, they are vanquished. The patient shows more interest, courage, and purpose of will or resolution, as well as powers of endurance. In a word, so uniformly is this the result of a few weeks of such electric treatment in suitable cases, that we here urge its use, by competent practitioners, as a most valuable adjunct medication, and well worthy of patient investigation, and improvement or adoption.

G. NOTE 1. (See page 384.) For *Thoracalgia* and *Infra-mammary Pain,* adopt the following method: First place the *negative* electrode at the

lower umbilical region, then with the *positive* sponge commence under the clavicles, bathing over the pectoral muscles, for a minute, and then over the whole thorax; mainly, or only, I should have said, on the *anterior* portion of it, — employing only medium strength current, and working *at first round about* the sore or painful places, then on to them, as well as about them, for 5 or 6 minutes more, or until all pain and soreness is chased away, so as not to be reproduced by full inspiration. Repeat the same daily a few times.

G. NOTE 2. (See page 383.) For *Epigastralgia*, and pains simulating dyspepsia, adopt the *double circle movements*, by placing the *positive* moist sponge *near* the tender spot over the stomach, while the other, negative, is placed somewhere below, on the abdomen or thighs, — i. e., far away, and that in a downward direction, — and thus commence moving both electrodes in circles, the one close about, and afterwards over, the tender stomach, while the other is performing a large part of a larger circle, and that mostly in a downward direction, which is to be continued for 5 or 10 minutes. The *positive* sponge must be moved as gently but as firmly as possible, without producing pain. Repeat this *seance* daily, or every other day.

G. NOTE 3. (See page 380.) The foregoing (Note 2) is the correct *process* for many cases of *irritable spine, local hyperæsthesia, rheumatism,* and *injury* of spine or ribs, (after leeches, cups, or blisters, where is inflammation) by operating close about and over the seat of pain or soreness, with the *positive* electrode, in like manner as described for epigastralgia, — say for 5 to 15 minutes, — always observing in such cases to work the *negative* electrode mainly in lateral and *downward* directions, — i. e., to the parts anterior and below the seat of difficulty. Such is the principle.

G. NOTE 4. (See page 384.) For *Cœlialgia*, or pains in the skin, fascia, and muscular tunics of the *abdomen*, first place the *negative* electrode at the inner sides of the thighs, or as low as the inner condyles of the knee joints, first on one, and then on the other, while with the *positive* perform circle movements about and over the affected part of the abdomen. But here be careful to distinguish such pains, from those that arise so severely, and not unfrequently, *from atony and relaxation of the underlying viscera*, as when the intestines give way to flatus or excrements, or as where, under a morbid nervous action, there is a *secreted* flatus in the bowels, uterus, or vagina, or there may be only a want of tone adequate to the free physiology. In these cases, therefore, we must, on the contrary, institute the methods laid down at F., Note 2, and at E., Note 1.

G. NOTE 5. For *Local Palsy of Sensation.* — First employ double circle treatments *with the negative electrode in the centre*, (see F.;) also the method laid down for paralysis in any of the limbs, which directs the current through the supplying nerve trunk, (see C.,) and next employ Duchenne's localized Faradaization. (See pages 238, 331.)

For *Dermatalgia*, which is a neuralgia of the skin, as well as for all hyperæsthesia of the sentient nerves, use the radiating circle treatments, as at G.,

Note 2, with the *positive* electrode in the centre. But if this is not sufficient, we must take the opposite course, and boldly resort to Dr. Duchenne's atrocious method, which he calls *localized Faradaization*, using a full battery current, or all the patient can possibly bear. (See page 389.) If the patient cannot bear it, or if the weaker current is not sufficient, then etherize the patient, and proceed with full battery power for 3 to 5 minutes; its curative effects will be about the same as if no ether had been given.

INDEX.